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THE UNIVERSITY OF ALBERTA

AN ECONOMETRIC ANALYSIS OF SOVIET WHEAT IMPORTS

BY

MARILYN GAIL JOHNSON

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH
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OF MASTER OF SCIENCE

IN

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DEPARTMENT OF RURAL ECONOMY

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled An Econometric Analysis of Soviet Wheat Imports submitted by Marilyn Gail Johnson in partial fulfilment of the requirements for the degree of Master of Science in Agricultural Economics.

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Date *October 9, 1987*

DEDICATION

To Mark

ABSTRACT

The objective of this study is to examine the wheat import behavior of the Soviet Union. This is accomplished through the development of an econometric model that equates world wheat demand with world wheat supply. The supply side of the model employs aggregate wheat exports from the five major exporting regions to represent available wheat for importing. The demand side of the model separates total world imports of wheat into wheat imported by the Soviet Union and wheat imported by all other importing regions.

The model was estimated by both a limited and a full information estimation technique. Based on the objectives of the study, the limitations of the data and apparent specification errors of the model, the estimated parameters from the limited information estimation technique were used for assessing Soviet import behavior.

Estimated model parameters suggest the volume of wheat imported by the Soviet Union is inversely related to the import price of wheat. Furthermore, the results suggest the Soviet policy changes, designed to improve Soviet citizens' dietary standards, have influenced their wheat import behavior in a positive manner. Production shortfalls appear to be at least partially supplemented with imports and the nature of the imports suggests that Soviet wheat imports are not altered by the quantities of wheat consumed as either human food or animal feed. However, within the Soviet Union the quantities of wheat consumed for food do not appear to increase as consumer incomes increase suggesting wheat for food purposes is an inferior good. In contrast, wheat used for livestock feed was directly related both to livestock inventories and the share of wheat produced in a given year relative to total grain production.

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There are many people I wish to thank for their support and assistance during my graduate program. I am most grateful to Dr. Michele Veeman, my adviser, for her steady guidance and sound recommendations throughout my masters program. For discussion of specific points contained in this thesis I am also indebted to Dr. D. Ryan, Department of Economics, for his very generous advise on econometric matters, Dr. J. Richter for his insightful comments on Russian agriculture and Dr. T. Manning the chairman of my oral examination.

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CHAPTER I

INTRODUCTION

Each year Canadian wheat producers harvest far more grain than can be consumed domestically. Excess wheat supplies and flours are sold in the world markets. This activity not only brings a return to prairie grain producers for their efforts but also has a very important spin-off effect on other sectors of the Canadian economy that are either wholly or partially dependent upon the agriculture industry for the business it generates.

Wheat exports have averaged 15.7 million metric tonnes over the past ten crop years. Of this export volume, approximately every fifth tonne of wheat was sold to the Soviet Union. Typically about 20 per cent of Canadian wheat exports are sold to the Soviet Union. This proportion, however, is larger if one includes wheat sales to the Soviet Union that are re-exported to other Soviet bloc countries.

As a major world wheat importer during the last fifteen years, the Soviet Union has purchased wheat from Canada more consistently than from the other major wheat exporters which comprise the United States, Argentina and Australia. This indicates the importance of the Soviet Union to Canada as a trading partner in the world wheat market.

World wheat market conditions in recent years have placed pressure on exporting nations. Burdensome stocks and increasing production levels for exporting countries have led to aggressive competition among the major exporting regions. Successful selling strategies for exporting nations in this environment will involve critically analyzing importers and their needs as well as monitoring the selling tactics of other exporters. Such strategies are needed to ensure that the Canadian share of the world wheat export market is maintained in such a competitive market environment. It is hoped that this study of the Soviet Union's demand for wheat imports, through the development of an econometric model, will prove useful in assessing this major importer's behavior as a buyer of Canadian wheat.

Purpose of This Study

The purpose of this study is to examine the demand for wheat imports of one of the world's major wheat buyers. Initial study suggested that this could be pursued through the development of an econometric model of Soviet wheat import demands. The model is constructed as a simultaneous equation model of supply and demand variables for which equilibrium involves equating the total world supply of wheat exports with the sum of Soviet wheat import demand and the demand for wheat imports by all other importing countries. This requires the specification of a Soviet wheat import demand function, an import demand function that explains the import behavior of the rest of the world's consuming nations and a function that could describe the supply of wheat exports for the world market.

Objectives of This Study

The specific objectives of this study are as follows:

- (i) To review the Soviet grain sector and examine how changes in Soviet policy have affected this sector.
- (ii) To identify variables that represent economic behavior in the aggregate world wheat export market and the Soviet wheat sector.
- (iii) To determine the causal chains that link the variables in economic relationships and thereby evaluate the kind of simultaneous behavior present in the model.
- (iv) To determine if the model is under-identified, over-identified or just identified and, based on this assessment, select the most appropriate estimation technique for the model.
- (v) To employ the appropriate estimation technique to estimate the model and examine the statistical properties of the estimated parameters.
- (vi) To use the estimated parameters in analyzing Soviet wheat import behavior.

Methodology

This study involves the development of an econometric model of Soviet wheat demand. The specification of the structural model is based on information determined in a review of the Soviet and world wheat markets and identification of the relationships inherent in these markets. An appropriate estimation procedure is selected using criteria dictated by model characteristics, study objectives and data limitations. Once the most suitable technique is selected and the model estimated, the statistical properties of the parameters are examined. The estimated parameters are then used in an analysis of Soviet wheat import behavior.

Organization of the Thesis

The remainder of this thesis is organized into four chapters, the contents of which are outlined briefly as follows. Chapter Two contains an overview of the Soviet grain sector and the impact that changing agricultural policies have had on this sector. This chapter also includes a discussion of previous studies that have employed econometric models to evaluate agricultural commodity markets. An overview of the theoretical framework applied in econometric model building is also provided. In Chapter Three the actual structural model employed in this study is discussed. Alternative estimation techniques are considered and a choice among them is made. Data sources and problems are also described. Chapter Four presents the estimated results and tests of significance while the final chapter provides a summary of the work, outlines conclusions and presents some recommendations for further study.

CHAPTER II

REVIEW OF THE LITERATURE

Background

The importance of agriculture to the Soviet economy has been recognized and studied for many years both by Soviet planners and Western analysts. Interest stems from the crucial role agriculture plays in the Soviet economy and the impact that the Soviet economy has on the remainder of the world.

Robert L Paarlberg (1985) has discussed how the Soviet Union's internal agricultural policies have shifted during the past seven decades and how this policy change was viewed by outside observers. The shift was referred to as moving from an outward looking food strategy to an inward looking strategy more sensitive to the domestic food needs of Soviet citizens; a shift that moved the Soviet Union from being the single largest grain exporter to a major grain importer. Early in this seventy year period, grain exports were maintained to finance rapid industrialization and consolidation of political control. Shifts away from this grain trade policy began with Khrushchev and his misgivings about existing policies that served external objectives first and domestic consumption needs last. In 1953 Khrushchev initiated agriculture policy reforms that led to increased capital investment and increased prices for farm products. In the early 1960s these changes took effect and overall production levels increased. An optimistic Khrushchev tried to restore the Soviet Union to its earlier position as a significant net grain exporter. When a major drought in 1963 suddenly cut production and the low domestic reserves were insufficient to prevent distress slaughter of livestock, the Soviet Union turned to the world market for imports rather than cut into domestic bread supplies. As this was a situation Khrushchev's successors did not want to happen again, the agricultural strategies implemented during Brezhnev's era further increased the allocation of resources committed to agriculture.

Under Khrushchev's leadership, the greatest gains to increasing agricultural output came from expanding the usage of virgin land, while under Brezhnev, gains had to come through increasing yields. Marginal returns were low from the increased investments and although yields showed some improvement, the growth in demand for grains exceeded the growth in supply of grains. Rapidly rising demand was a reflection of Brezhnev's decision to orient domestic agricultural policies towards increased animal protein output for Soviet diets. As food consumption rose, the Soviet Union turned more and more heavily to world markets to acquire the necessary grain supplies. While outside observers watched the Soviets as active buyers during the 1960s in world markets, it was not until 1971 that evidence of the Soviet policy change became conclusive in actual trade behavior. (Johnson, 1977, p.21 and Paarlberg, 1985, p.81)

Tables 2.1 and 2.2 provide some indication of the change in the Soviet trade behavior relative to domestic production levels. Although the Soviet harvests of 1970 and 1971 were of record size, the Soviets increased grain imports substantially and decreased grain exports in 1972. It is also evident from the data in Table 2.3 that the proportion of grain consumed as feed continued to increase, exceeding twice the volume of grain fed to livestock only ten years earlier in the early sixties.

Paarlberg (1985, p. 99) concluded that although Khrushchev added the pursuit of domestic food policy objectives to Soviet policy, it was not until the Brezhnev era that it was recognized and accepted that to pursue food policy objectives at home would require some sacrifice of external needs. By presiding over the Soviet transformation from a net exporter of grain (as late as 1970) to the world's single largest grain importer, Brezhnev was accepting a near total reversal of earlier food policy.

Alterations to food policy priorities are also evident in consumption patterns within the Soviet Union. This element of Soviet behavior was examined by the Organisation for Economic Co-operation and Development (OECD) in 1983. Their study recognized that living standards, as shown by food consumption, have risen since 1960. Figures in Table 2.4, which represent per capita consumption of selected foods, reflect such a rise. Consumption of animal products

increased substantially during the 1960-1980 period while the per capita consumption of potatoes and grain products fell. However, in most cases these increases fell short of Soviet goals. The OECD suggested such a lag behind targets was a function of (1) disappointing agricultural production; (2) underdevelopment of the food processing industry including lack of processing capacity, unsatisfactory quality, assortment and distribution and; (3) limitations inherent in the centralized economic system.

TABLE 2.1

IMPORTS AND EXPORTS OF TOTAL GRAIN AND WHEAT, USSR, 1960-84
(metric tons)

	<u>Total Grain*</u>			<u>Wheat and Flour Equiv.</u>		
	<u>Imports</u>	<u>Exports</u>	<u>Net Imp</u>	<u>Imports</u>	<u>Exports</u>	<u>Net Imp</u>
1960	773,900	6,866,800	(6,092,900)	121,500	5,662,100	(5,540,600)
1961	729,700	7,830,400	(7,100,700)	678,400	5,147,433	(4,469,033)
1962	413,300	8,175,300	(7,762,000)	75,800	5,111,061	(5,035,261)
1963	3,631,100	6,655,800	(3,024,700)	3,437,500	4,486,464	(1,048,964)
1964	8,994,500	3,963,000	5,031,500	8,631,400	2,474,980	6,156,420
1965	7,014,500	4,703,800	2,310,700	6,776,600	2,029,574	4,747,026
1966	8,469,500	3,985,400	4,484,100	8,030,600	3,227,834	4,802,766
1967	2,876,100	6,775,300	(3,899,200)	2,122,000	5,805,153	(3,683,153)
1968	2,229,763	6,202,485	(3,972,722)	1,705,500	5,137,285	(3,431,785)
1969	1,242,875	8,048,526	(6,805,651)	417,800	6,800,505	(6,382,705)
1970	2,832,470	6,918,330	(4,085,860)	2,205,773	5,922,444	(3,716,671)
1971	3,971,290	9,573,230	(5,601,940)	2,688,087	8,512,736	(5,824,649)
1972	16,160,940	5,090,680	11,070,260	8,481,142	4,433,107	4,048,035
1973	24,379,370	5,812,140	18,567,230	15,625,867	5,051,268	10,574,599
1974	7,754,830	8,474,910	(720,080)	3,145,464	6,533,454	(3,387,990)
1975	16,655,430	4,413,730	12,241,700	9,616,681	3,472,008	6,144,673
1976	21,427,580	2,383,530	19,044,050	7,214,024	1,691,481	5,522,543
1977	11,811,800	4,676,190	7,135,610	7,142,293	2,966,013	4,176,280
1978	23,489,570	2,454,740	21,034,830	9,363,474	2,217,934	7,145,540
1979	26,865,780	3,903,100	22,962,680	10,349,421	3,657,833	6,691,588
1980	31,226,570	2,286,960	28,939,610	16,032,045	2,104,490	13,927,555
1981	43,670,600	2,636,110	41,034,490	18,677,758	2,395,910	16,281,848
1982	40,113,350	2,236,800	37,876,550	22,159,720	1,970,760	20,188,960
1983	32,131,810	2,265,530	29,866,280	22,248,320	2,092,110	20,156,210
1984	43,214,170	2,135,110	41,079,060	27,279,360	1,930,900	25,348,460

SOURCE: F.A.O. Trade Yearbook, various issues.

* Includes wheat and meslin, rice, barley, maize, rye, oats, cereals n.e.s. and flour in grain equivalents.

TABLE 2.2

AREA AND PRODUCTION OF TOTAL GRAINS AND ALL WHEAT
USSR, 1961-1986

	<u>Area</u>		<u>Production</u>	
	<u>Total Grain</u> (^{'000s hectares})	<u>All Wheat</u>	<u>Total Grain</u> (^{'000s metric tons})	<u>All Wheat</u>
1961	121,771	63,000	132,863	66,483
1962	121,476	67,411	132,604	70,778
1963	119,150	64,609	99,463	49,688
1964	122,678	67,887	140,960	74,399
1965	121,265	70,205	114,452	59,686
1966	124,807	69,958	171,184	100,499
1967	122,172	67,026	147,887	77,419
1968	121,472	67,231	169,540	93,393
1969	122,703	66,426	162,402	79,917
1970	119,261	65,230	186,795	99,734
1971	117,937	64,035	181,175	98,760
1972	120,158	58,492	168,238	85,993
1973	126,738	63,155	222,530	109,784
1974	127,187	59,676	195,708	83,913
1975	127,920	61,985	140,118	66,224
1976	127,760	59,467	223,755	96,882
1977	130,344	62,030	195,727	92,161
1978	128,465	62,898	237,390	120,936
1979	126,351	57,682	179,176	90,207
1980	126,608	61,475	189,090	98,182
1981	125,559	59,232	160,000	80,000
1982	123,012	57,278	180,000	86,000
1983	120,809	50,823	190,000	79,000
1984	119,612	51,061	170,000	73,000
1985	117,939	50,265	190,000	83,000
1986	118,000	49,000	190,000	80,000

SOURCES: USSR Situation and Outlook Report, USDA, ERS, May, 1984 and May, 1986.
USSR Agricultural Situation Review of 1978 and Outlook for 1979, USDA, ERS, 1979.
Agricultural Situation of the Soviet Union. Review of 1974 and Outlook for 1975, USDA, ERS, April, 1975.
F.A.O. Production Yearbook, Volumes 18, 21 and 23.

TABLE 2.3

TOTAL SOVIET GRAIN PRODUCTION AND QUANTITIES OF TOTAL GRAIN, COARSE
GRAIN* AND WHEAT FED, 1960/61 TO 1986/87
(million metric ton)

Year begins July 1	Total Grain Prod	Total Grain Fed	%Total Grain Fed	Total Wheat Fed	%Wheat of Total Grain Fed	Total C.Grains* Fed	%C.Grains* of Total Grain Fed
1960/61	125.5	41	33%	10	24%	31	76%
1961/62	132.9	45	34%	13	29%	31	69%
1962/63	132.6	43	32%	8	19%	31	72%
1963/64	99.5	32	32%	3	9%	25	78%
1964/65	141.0	44	31%	9	20%	31	70%
1965/66	114.5	56	49%	20	36%	31	55%
1966/67	171.2	60	35%	16	27%	40	67%
1967/68	147.9	64	43%	20	31%	39	61%
1968/69	169.5	72	42%	27	38%	40	56%
1969/70	162.4	83	51%	34	41%	44	53%
1970/71	186.8	92	49%	39	42%	49	52%
1971/72	181.2	93	51%	36	39%	51	55%
1972/73	168.2	98	58%	41	42%	53	54%
1973/74	222.5	105	47%	30	29%	70	67%
1974/75	195.7	107	55%	34	32%	68	64%
1975/76	140.1	89	64%	30	34%	56	63%
1976/77	223.8	112	50%	28	25%	78	70%
1977/78	195.7	122	62%	44	36%	74	61%
1978/79	237.4	125	53%	43	34%	79	63%
1979/80	179.2	123	69%	53	43%	68	55%
1980/81	189.1	119	63%	48	40%	67	56%
1981/82	160.0	116	73%	42	36%	71	61%
1982/83	180.0	117	65%	45	38%	68	58%
1983/84	190.0	120	63%	36	30%	77	64%
1984/85	170.0	121	71%	36	30%	80	66%
1985/86	190.0	121	64%	36	30%	76	63%
1986/87	190.0	121	64%	34	28%	80	66%

SOURCES: USSR Situation and Outlook Report, USDA, ERS, May, 1986.
USSR Agricultural Situation Review of 1978 and Outlook for 1979, USDA, ERS, 1979.
Prospects for Soviet Agricultural Production and Trade, p.99, OECD, 1983.
F.A.O. Production Yearbook, Volumes 18, 21 and 23.

* Coarse grains include rye, barley, oats, corn and millet.

TABLE 2.4

PER CAPITA CONSUMPTION OF SELECTED FOODS, USSR,
SELECTED YEARS 1950 TO 1984 AND 1990 PLAN

Year	Meat & Fat	Fish & Prod.	Milk & Prod ¹	Eggs ²	Potatoes	Grain ³	Fruit Veg ⁴
				Kilograms			
1950	26	7.0	172	60	241	172	62
1960	40	9.9	240	118	143	164	92
1970	48	15.4	307	159	130	149	117
1980	58	17.6	314	239	109	138	135
1981	57	18.0	304	247	104	137	139
1982	57	18.4	295	249	110	137	143
1983	59	17.4	313	256	109	134	146
1984	61	17.5	319	258	108	133	147
1990 Plan	70	19.0	330-340	260-266	110	135	192-205

SOURCE: U.S.S.R. Situation and Outlook Report, USDA, May 1986.

1 Including milk equivalent of butter.

2 Number.

3 Flour Equivalent.

4 Includes fruits and berries as well as vegetables and melons.

The first of the three explanations for the under achievement of Soviet targets suggested by the OECD appears to have had the most direct impact upon Soviet trade behavior. D. Gale Johnson (1977, p.13) suggested that although Soviet agricultural output had increased at an annual rate of 3.9% from 1950 to 1971, (compared to 2% annually for the U.S.A.) the growth rate of agricultural output was only part of the story. Other factors that needed to be considered, according to Johnson, included output growth in relation to demand growth, costs of producing livestock products and the level of investment devoted to agriculture. Although output growth had been rapid, it had been lower than the rate of growth in demand. This has led to an increased dependence on imported grains and feedstuffs. Demand growth has increased not only because of substantially increased income levels but also due to retail prices of meat and milk remaining at 1962 levels. Livestock costs of production are high in relation to western standards due in part to very high feed conversion factors. While investments in the agricultural sector have been increasing, the marginal returns are low due to inefficiencies in the centralized system.

The OECD report suggested that for consumption goals to be achieved, the present supply-side bottlenecks must be reduced or eliminated. It was recognized that the present Soviet agricultural situation is not a result of stagnating growth but rather one of crop and animal production growing, on the whole, faster than the population but with wide fluctuations in output levels from year to year. Harvest shortfalls in individual years have contributed to an overall lack of sufficient output growth even though the output trend during the past twenty years has been increasing. Wide fluctuations in grain output, when coupled with lack of storage facilities, creates difficulties in supplying grain to the livestock industry.

As consumption goals are repeatedly unattained, the OECD pointed out that the Soviet grain problem is becoming more and more a problem of animal production. Livestock inventories are increasing faster than forage crop output, causing an increasing share of grain output to be used for feed. This is evident in the figures contained in Table 2.3. Also, the composition of Soviet grain imports has changed to reflect an increase in the demand for feed grains (See Table 2.5). Given an arable land base which is unlikely to be substantially increased, it was suggested that Soviet efforts must now focus on raising yields, both of grain and forage crops. This would involve seeding the most suitable species and variety of grain in each local area at the expense of less productive ones. Such action, the OECD suggested, would see an increase in winter wheat, (which has much lower yield variability than spring wheat) winter rye, barley, oats and maize in the southern regions. A change in the cropping pattern to higher yielding crops may aid in attaining an increased total output. In the past feed grains were more or less neglected in favor of bread wheat. The OECD pointed out, however, that a change to increased feed grain production has become evident. This view is supported by the observed decline in the portion of wheat fed and wheat's share of total crop production (See Tables 2.2 and F.1).

TABLE 2.5

COMPOSITION OF SOVIET GRAIN IMPORTS BY TYPE OF GRAIN,
1960-1984 (expressed as per cent)

<u>Grain</u>	<u>1960-1964</u>	<u>1965-1969</u>	<u>1970-1974</u>	<u>1975-1979</u>	<u>1980-1984</u>
Wheat	88.9	87.2	58.2	43.6	55.9
Maize	0.9	5.8	25.6	48.4	28.4
Other Grains	10.2	7.0	16.2	8.0	15.7

SOURCE: FAO, Trade Yearbook, various issues.

A final problem with Soviet agriculture relates to the lack of storage facilities and the transportation system which is unable to cope with peak harvest workloads. The OECD estimated that in 1980, Soviet storage capacity was 90-100 million metric tons below what was needed. This situation has improved gradually as new facilities have been constructed and existing structures reconstructed. Losses from inadequate storage facilities were estimated by the OECD to be likely to continue and thereby limit the possibility of offsetting a disappointing harvest with grain stored from record production years. The OECD also indicated how transportation capabilities have restrained Soviet agricultural performance. Harvest times place seasonal strains on the transportation system. Grain must be moved from fields to collection points by trucks. From there grains are typically moved to processing, industrial or feed enterprises by rail or inland waterways. While the second phase of grain movements appears capable of coping with greater distances and increased grain output, the first phase, which relies on motor vehicles, is a real bottleneck in Soviet agriculture. Motor vehicles are too few in number and of poor condition for the work involved. Also, the road networks are reported to be inadequate for transportation needs and in many cases these are only finished with a natural surface rather than being hard surfaced for all weather usage. On the whole, the OECD concluded, the transportation bottlenecks during harvest, and the cost of grain losses connected with it, will persist for some time to come.

The Soviet decision to increase production and consumption of meat and dairy products has augmented the need for feed grains. Direct repercussions of this decision are felt specifically in wheat markets because some low quality domestically grown Soviet wheat may be channelled

into feed grain usage while some wheat for food is acquired through purchases on the world market (Kostecki, 1984).

Previous Studies of Soviet Grain Imports

The need to identify and/or estimate the impact of Soviet grain imports has been recognized and studied by relatively few scholars. Studies that have been undertaken cite the substantial size and timing of the Soviet imports in relation to world trade as a major reason for studying this particular country's trade patterns.

Generally the focus of these studies has been on all grain imports. However, Padma Desai (1982) has examined both total Soviet grain imports and, in less detail, Soviet wheat imports. Desai employed three alternative methods to estimate annual Soviet imports of grain and wheat between 1981 and 1985. The approaches were all kept deliberately uncomplicated relative to the methods usually used for prediction by economists. It was felt that the limited availability and, at times, complete absence of necessary data dictated such an approach. The three methods and their merits are discussed and evaluated in terms of this study.

The first two of Desai's three approaches to forecasting Soviet grain imports considered imports as the quantity deficit between grain production and the requirements for feed, seed, industrial and human consumption, dockage waste, export commitments and grain reserves. Forecasts of both future output levels and grain requirements were based upon past patterns. In the first method, each of the output and usage values were estimated on the basis of the linear trend of past behavior. In the second method, a production function was used to estimate output levels but the same grain requirement values projected in the first method were employed. Finally, in the third approach grain imports were determined directly from a regression estimate of an import demand function in which the explanatory variables were domestic production, price per tonne of imports and a dummy variable to account for policy changes. The values of the explanatory variables used in the forecast period were either those calculated using the first two methods, or values the author felt would reflect Soviet economic behavior.

Due to the wide weather-related fluctuations in Soviet grain output, Desai made three different sets of forecasts for the different estimating methods. One set of weather factors assumed above average conditions, one below average conditions and one average weather conditions. Production and dockage levels reflected either an adverse or a favorable weather impact. The residual import projections were therefore presented as a range of values rather than an exact figure to account for the different weather conditions that could prevail.

Wheat imports were forecast using only the first technique where the output and usage level estimates were obtained from a linear trend of past performances. Desai encountered problems estimating wheat usage for livestock feed because of the possible substitution of coarse grains for poor quality feed wheat when the price or supply situation dictated such behavior. As a solution to this difficulty, Desai assumed there would be some substitution in favor of coarse grain and that as the total feed grain use increased with livestock inventories, the use of feed wheat would remain constant and thus constitute a declining share of total feed grain supplies.

Desai concluded that all the approaches presented for forecasting Soviet grain or wheat imports produced comparable results. All three methods projected grain imports to be within similar weather related ranges. Desai also determined the Soviet Union to have sufficient currency to purchase the projected grain imports given the grain price projections presented in World Bank data.

Karl D. Meilke and Harry de Gorter (1986) also studied wheat imports with the use of an econometric model. They employed a recursive model that could be used in evaluating impacts of alternative policy scenarios that have occurred or may be implemented in the future. Although the subject of their model was the EEC member countries, there is merit in examining the modelling techniques utilized to determine how such techniques could apply to a different region.

The use of a recursive model demonstrated Meilke and de Gorters' recognition of the interrelatedness inherent within grain markets. In fact, this model was constructed with five clearly

defined interrelated subsectors or "blocks" of the wheat industry. These are supply side variables, demand side variables, farm price variables, policy variables and ECC member country price variables.

Such an interrelated approach more closely represents the true relationships that are likely to exist between economic variables in the grain trade than does a single equation linear demand function. Yet, a recursive relationship between endogenous variables within a model implies a causal dependence from one period to the next. (Labys, 1973, p.128) Since a commodity model is an attempt to formally represent a market where the behavioral relationships selected reflect the underlying economic laws, an import demand model for wheat could require the variables within the system to be solved simultaneously rather than recursively. A simultaneous solution allows for more dependence among variables than a recursive solution where endogenous variables may be estimated independently of others. This suggests that the recursive/block approach used by Melike and de Gorter above may not be the most appropriate representation of the wheat industry.

Donald W. Green (1979) successfully applied the simultaneous equation technique to analyze Soviet agriculture. This paper presented a model builder's perspective of Soviet agriculture with specific results given for the following major components: crop production, the livestock sector, labor participation, and capital investment. Projections were made for grain and meat output over the period of the eleventh five year plan (1981-1985). While this was a large macroeconomic model concerned with a more complete study of the Soviet economy, the treatment of the grain sector is relevant to this study and will therefore be discussed here.

Green examined total crop production and its effects on the growth of the livestock herds, feed allocation and the determination of animal product output and meat production. Simultaneity of output variables and inputs led Green to employ a model with simultaneous equations. Crop production was placed at the center of the agricultural model. Recognition was made of the variation between normal and actual crop production. Normal production was estimated as a function of seeded area, employment, fixed capital and material inputs while actual production

levels reflected the effect of weather conditions. The choice of this formulation was justified by Green's concern in determining how deviations from normal agricultural output influence new capital investment along with state budgets and defense expenditures.

Self Shalaby and James Hassler (1985) also used a system of equations when they assessed wheat import demands in South American countries. They employed Zellner's Seemingly Unrelated Regression (SUR) estimation technique. This approach was considered particularly relevant by the authors of this study as it allowed for tests of hypotheses across countries or across equations.

Shalaby and Hassler estimated per capita wheat imports as a function of the following explanatory variables: real border price of wheat, per capita real gross domestic product, real border price of rice imports, per capita domestic production of wheat, a lagged dependent variable, and a dummy variable to account for structural shifts.

Masayoshi Honma (1982) estimated Soviet wheat imports as part of a much larger econometric analysis of world wheat trade. Import demand was regressed on the import price of wheat, wheat inventory levels and a dummy variable to explain the shift in Soviet food policies. The time frame examined spans the period 1962-1978 and includes the 1971 Soviet shift from outward looking to inward looking food policies. A dummy variable was used to take account of this shift by assigning those years greater than or equal to 1971 a value of one while all other years were assigned a value of zero. Price and inventory variables were found to have an inverse relation with imports. Import demand varied directly with the dummy variable. All the coefficients were statistically significant at the 5 percent level. Honma anticipated that both domestic production and income would have some explanatory power. However, neither showed significant coefficients. Given the time lag of imports which may be used to make up part of any production shortfall, Honma theorized that the significant lagged inventory variable accounted for production fluctuations in the import demand regression. It was further suggested that import demand might be a function of lagged production in the USSR since lagged inventories are strongly related to lagged production.

Theoretical Framework

Development of a wheat import demand model for the Soviet Union follows model building techniques outlined by Walter C. Labys (1973) and the related elements of the papers reviewed earlier in this chapter. Labys provides an overall reference for model building as he draws together the results obtained from econometric research in both microeconomics and macroeconomics.

Before considering what estimation technique would be suitable for solving any econometric model, Labys discusses three steps to consider in formulating a model's structure. First is the specification of the model. This involves reviewing the economic structure of the market or industry under study and selecting those economic variables which best describe the structure. All variables should be defined and specified as either endogenous or exogenous to the model. Also, any economic relations that exist between the variables should be combined in equations in a way consistent with economic theory. If possible, all assumptions used in the specification process should be justified.

Once the variables and structural equations linking them have been specified, Labys recommends that lines of causality within the model be examined to determine if the relationship between the variables is recursive or simultaneous. Causality, or interdependence, among the endogenous variables must be determined in the model to prevent either specification errors or having estimated parameters that do not meet *a priori* expectations.

Two factors, in particular, will aid in determining causality: (i) the chain of response existing in the market, and (ii) the length of the data interval relative to the time lags between variables. If a system of equations is recursive, then the endogenous variables enter the system one at a time. One variable will impact on another in a successive manner resulting in a causal chain. Also characteristic of recursive models is the absence of any correlation between disturbance terms of separate equations. If a system is recursive, it may be estimated with ordinary least squares applied in succession to the equations.

By contrast, if a system of equations is simultaneous, then the variables determined within the system are jointly dependent. The system of equations jointly determines the values of the endogenous variables in terms of values of the predetermined variables, any endogenous variables included in the set of explanatory variables and the stochastic disturbance terms. Labys suggested that the availability of data often determines the unit of time selected for a commodity model as well as the degree of aggregation. For example, if only annual data are available and the actual time lags existing between the variables are likely to be less than one year, then the dependency between variables is simultaneous in nature.

In a simultaneous model endogenous variables will be included among the set of explanatory variables in some equations. This inclusion of the endogenous variables on the right-hand side implies a two-way causation between endogenous and exogenous variables rather than the one-way causation of the stochastic regression model. If the ordinary least squares estimation technique is applied to an equation with two-way causation, the estimated parameters will be inconsistent because of the possible correlation between the disturbance term and any endogenous variables included in the explanatory variables of the equation. Furthermore, the disturbance terms of each structural equation may be contemporaneously correlated with the disturbance terms of other structural equations.

If a system has simultaneous causality, then more elaborate methods of estimation are required to account for any dependency between the disturbance term and endogenous variables appearing in the set of explanatory variables for that equation. However, before attempting any estimation of the model it is necessary to check the identifiability of the model to ensure that estimates may indeed be found for the model. This is the final step prior to estimation of the model.

It is recognized that the structural equations describe the economic relationships of the model. Each structural equation expresses an endogenous variable as a function of other endogenous variables, predetermined variables and random variables. Structural parameters of a system of equations are estimated from the reduced form of the model which expresses each

endogenous variable as a function of the predetermined variables, structural parameters and error terms of the model. However, unscrambling the structural parameters from the estimated reduced form of the model is not always possible. Model identification concerns this question of whether numerical estimates of the structural parameters may be obtained from the estimated reduced form of the model, and if so, whether they can be obtained uniquely.

To determine whether structural parameters in any equation can be recovered from the reduced form of the model, it is useful to rewrite each structural equation in terms of all the variables included in the structural function as well as those variables appearing elsewhere in the system within other structural equations. Those variables that appear elsewhere in the system but not in the structural equation itself are given zero coefficients. Including all variables of the system, whether they appear in the structural relationship or not, provides a way to identify a function in terms of what variables it does not include. That is to say, if a variable appearing elsewhere in the system has no influence on the economic relation in a particular equation, then the parameter on that variable in that particular equation is set to zero. These so called zero restrictions can provide a way of determining if the non zero parameters appearing in that structural equation can be estimated, and if so, whether unique estimates will be obtained. This procedure of determining identification of an equation from the variables that are absent from that equation has been called the paradox of identification (Koutsoyiannis, p.349).

For its parameters to be identified, each equation in system of equations must not include a certain number of the variables contained in other equations of the system. That is to say, each equation must contain one or more variables with a zero coefficient, where these variables with zero coefficients are active variables in other equations of the model. As active variables in other equations, these variables will change over time and cause shifts in other equations of the model but not in the equation where they have zero coefficients. This provides for a distinction between the equation which contains the zero coefficient restrictions on these variables and other equations where the variables are active explanatory variables.

Identification of an equation may be determined by either the order condition (a necessary but not sufficient condition) or the rank condition (which is both a necessary and sufficient condition). The order condition is the easiest condition to check because it only involves counting the variables included and excluded from each equation. If the total number of variables excluded from an equation but included in other equations is greater than or equal to one less than the number of equations in the model, the equation is considered identified by the order condition. This is necessary but not sufficient to ensure identifiability. The rank condition, however, is both a necessary and sufficient condition for the identification of an equation. It states that an equation in a model is identified if at least one non-zero determinant may be constructed from the matrix of the coefficients excluded from that particular equation but contained in the other equations of the model. This in essence ensures linear independence between the zero restrictions in each of the equations of the model and thereby permits mathematical solutions to be found for the structural parameters from the reduced form equations.

In short, identification of a system involves the identification of each of its equations by either the order or rank condition. It should be noted as well that there are two possible identification situations for a system. The first is when one or more equations in the system are under-identified. In this situation the rank or order condition is not satisfied and it is impossible for all structural parameters to be estimated. The second situation is where the equations are all identified. Identified equations may be either exactly identified or over-identified, with the difference being that the former indicates that unique values of the structural coefficients exist while in the latter case more than one value may exist for some of the structural parameters. Each situation of identification will require different estimation techniques.

Labys made the generalization that identification is not typically a serious problem with commodity models because most systems contain a large number of predetermined variables resulting in over-identification. It is nevertheless very important to examine the identification of a model as this is one of the factors that will determine which estimation technique is appropriate. Since models may be under-identified, exactly identified or over-identified depending on whether

the model is complete (ie. the model contains the same number of equations as endogenous variables) and satisfies the rank condition, each model must be examined to learn its level of identification.

Once the model is identified and the purpose of estimating the model is clearly defined, a model builder may proceed to select the most appropriate estimation technique. The three steps outlined above are not performed in isolation from each other. One cannot structure a model without considering these steps simultaneously. It is common in literature to refer to all three procedures under the broad category of identification. Nevertheless, this itemized discussion proves useful in describing the preliminary analysis that is required before estimating any econometric model.

CHAPTER III

MODEL SELECTION

As discussed in the previous chapter, before an econometric model can be estimated the model must be correctly specified and the proper estimation technique selected. Labys (1978, pp.122-123) has suggested that model specification depends upon the structure of the economic environment that is being represented by the model. The selection of the estimation technique, however, is dependent upon many factors such as the purpose of the model, how the model has been identified, the presence of endogenous variables among the set of explanatory variables, the availability of data concerning the model and the importance attributed to the various statistical properties of the estimates (Koutsoyiannis 1984, p.498) .

Model Specification and Purpose

The purpose of constructing the model for this study is to analyze Soviet wheat imports. Intriligator (1978,p.5) indicated that analysis of an economic situation involves obtaining empirical evidence that will evaluate the explanatory power of economic theory. If the estimated coefficients of the economic relationships are reliable, then parameters of economic theory such as elasticities or multipliers may be determined. The empirical evidence will then be useful in analyzing the behavior of the situation under study; namely the Soviet Union's demand for wheat imports.

As the purpose for estimating the model to be constructed here is primarily analytical in nature, it is necessary to choose an econometric technique that will estimate the individual structural parameters to meet this objective. Since it is planned to use the estimated coefficients to establish the values of economic parameters, it is desired that the estimation procedure result in estimates that are unbiased as well as consistent. Also, given the limited availability of data, as is

the case with any study involving the Soviet Union, the sample size is small. Under these circumstances unbiasedness and minimum variance are the statistical properties most preferred.

Model specification is determined on the basis of a review of the structure of the Soviet and world wheat markets and selection of those economic variables that appear to best describe this structure. The world wheat market is perceived to be composed of countries that tend to be major exporters and those that appear to import wheat on a regular basis. The five major exporting regions have been the U.S., Canada, Argentina, Australia and the E.E.C. with the composition of the E.E.C. member countries changing over time (See notes to Appendix C Table C.1). Wheat importing nations, by contrast, have been far greater in number. Within this market structure the Soviet Union has, over time, participated as both an exporter and an importer (See Table 2.1). With the exception of the years between 1964 and 1966 the USSR was a net exporter of wheat and wheat flour during the 1960's. At that time Soviet grain exports were comparable to those of Australia and exceeded Argentina's exports (D. Gale Johnson, 1977, p. 5). By 1970, however, Soviet wheat exports had dropped dramatically from several million metric tons per year to only a few hundred thousand metric tons each year. This drop in exports continued while the volume of wheat imports rose. By the 1980's the USSR was consistently importing over 1 million metric tons of wheat per year.

Given that the objective of this study is to examine Soviet wheat import behavior, a model is developed to analyze Soviet trading actions within the greater world wheat market. This involves identifying those variables that describe Soviet wheat import behavior, the aggregate wheat import behavior of the other importing regions and the aggregate behavior of the major exporting regions. These variables, when combined within a supply and demand model, provide a model of the world wheat market. Specifically, it is assumed that aggregate supply from exporting regions could be equated with the sum of Soviet demand and aggregate demand by other importing countries to provide an explanation of the individual components of the model.

The selection of variables to describe wheat demand begins with traditional import theory and relationships as outlined by Honma (1982, p. 34) where import demand is represented by

domestic consumption, inventory changes and domestic production. In the development of the model it is necessary to accommodate the specific characteristics of the environment that this model is attempting to represent. Due to the absence of published data on Soviet wheat inventories, the proxy variable of lagged Soviet wheat production is used in its place. This is based upon the suggestion by Honma (1982, p. 84) that Soviet wheat imports would be strongly influenced by lagged inventories which in turn would be related to lagged production; therefore, wheat imports could be considered as a function of lagged production in the USSR in lieu of unpublished wheat stock figures.

This relationship between stocks and lagged production is further explained by a stock adjustment theory as follows:

$$(1) \quad \Psi_t = \beta_0 + \beta_1 \Gamma_t^* + \mu_t$$

where stocks in a period, Ψ_t , are a function of the expected production in that period, Γ_t^* . Since expected production levels for the current period are not observable they are expressed in terms of known variables.

$$(2) \quad \Gamma_t - \Gamma_{t-1} = \Phi (\Gamma_t^* - \Gamma_{t-1})$$

The actual change in production, $\Gamma_t - \Gamma_{t-1}$, is some fraction, Φ , of the desired change in production for that period, $\Gamma_t^* - \Gamma_{t-1}$. The adjustment mechanism of equation 2 can alternatively be written as

$$(3) \quad \Gamma_t^* = 1/\Phi \Gamma_t + (1 - 1/\Phi) \Gamma_{t-1}$$

Substituting equation (3) into (1) gives

$$(4) \quad \Psi_t = \beta_0 + \beta_1 \Gamma_t + \beta_2 \Gamma_{t-1} + \mu_t$$

where the β_1 coefficient represents current production and β_2 lagged production. The stocks in time period t are weighted by production in periods t and $t-1$ with $1/\Phi$ and $(1 - 1/\Phi)$ representing the weights. This adjustment theory provides a link between the level of wheat stocks in a period and wheat production in a previous period.

Soviet domestic wheat consumption is disaggregated to account for the two major Soviet wheat usages: human food and animal feed. It is anticipated that consumption demand for food

wheat would follow consumer theory where an individual's demand may be represented as a function of the price of the good, the price of a substitute good and consumer income. Feed wheat usage is theorized to be a function of livestock inventories as well as the availability of alternate feed sources such as forage crops and root crops. The availability of other feed grains relative to wheat supplies may also have some bearing on the amount of wheat consumed as animal feed.

Wheat import behavior for the rest of the world's (ROW) importing regions also follows traditional import theory and relationships as outlined above. There are some doubts about the level of explanatory power of this equation due to the degree of aggregation involved. After all, this equation attempts to describe the importing behavior of developed countries, developing countries and centrally planned economies. Also, with simultaneous systems, a misspecification of this equation will affect the parameters in all other equations. Although the explanatory power of this equation is not expected to be high, such an equation is needed to complete the demand side of the world wheat market model since all countries do not produce wheat for the sole purpose of exporting just to the USSR.

Wheat demand for the ROW's importing nations is expected to be a function of wheat inventories in these regions (calculated as world wheat stocks less stocks in the exporting regions), wheat production (estimated as the residual of world wheat production less production in the USSR and the exporting regions), domestic wheat consumption (calculated as the residual of world consumption levels less that of the USSR and the exporting regions) and the world price of wheat. Due to the difficulties in aggregating prices and incomes across such diverse populations, consumption by the ROW's importing nations will not be disaggregated into specific uses as with Soviet consumption.

Wheat supply of the aggregated exporting regions is derived from the assumption that wheat supplies available for export were the residual of a producing region's wheat production plus imports and carryover less domestic consumption. Wheat imports and exports will be combined into a single net export variable for the exporting regions. These variables are

combined in equations to describe the relationships involved and the equations are then combined in a model to provide the supply side of the world wheat market. Again there is concern over the degree of aggregation involved because the agricultural policies and production practices vary so much for these regions.

The model is closed by equating demand with supply plus any changes to world wheat inventories. It is anticipated that a description of the world wheat market in this fashion will provide a model that can facilitate the examination of Soviet wheat imports within the world market. The application of a simultaneous equation estimation technique to this model will provide an extension of the single equation regression technique employed by Desai (1982) to estimate Soviet grain imports. Using Desai's explanatory variables of grain output, price of imports, livestock inventories and a policy dummy variable in several equations rather than just in one creates the opportunity for describing additional relationships involved in Soviet import behavior.

The selection of additional variables to describe such behavior is guided by the study of Honma (1982) in which he examined Soviet wheat imports within a much larger economic analysis of world wheat trade. Honma (1982, p. 83-84) regressed import demand on the import price of wheat, wheat inventories (as calculated by him) and a policy dummy variable to explain shifts in Soviet food policies. Honma found these variables were all significant and considered that their effects on the dependent variable corresponded to *a priori* reasoning. Other variables that Honma (1982, p.83-84) also anticipated to have some explanatory power were domestic production and income. However, neither of these variables had significant estimated coefficients.

Description of the Model

The specific variables initially selected for the model and the interrelationships that describe the structure of this market are presented below. Variables that are classified as jointly dependent (endogenous) are identified by an asterisk while the predetermined (exogenous) variables have no identification markers. The subscript "t" refers to a particular year in the 25-year

time period, that is, $t=1$ for 1960/61 and $t=25$ in 1984/85. The subscript " $t-1$ " refers to a lag of one period or one year. The model is:

- (1) Soviet demand for wheat imports:

$$SIMP_t^* = f_1 (SPROD_{t-1}, FOOD_t^*, FEED_t^*, WP_{t-1}, DY)$$

- (2) Soviet wheat used for human food:

$$FOOD_t^* = f_2 (INC, WP_t, SP_t)$$

- (3) Soviet wheat used for animal feed:

$$FEED_t^* = f_3 (SHARE_t, INV_t, HAY_t)$$

- (4) Rest of world demand for wheat imports:

$$RIMP_t^* = f_4 (RSTK_{t-1}, RCON_{t-1}, RPROD_{t-1}, WWP_{t-1})$$

- (5) Total demand for wheat imports:

$$TIMP_t^* = SIMP_t^* + RIMP_t^*$$

- (6) Exporting regions' net wheat exports:

$$XNEXP_t^* = f_5 (XPROD_{t-1}, WWP_{t-1})$$

- (7) Exporting regions' aggregate wheat production:

$$XPROD_t^* = f_6 (XYLD_{t-1}, XCO_{t-1}, WWP_{t-1})$$

- (8) Total supply of wheat for exports:

$$TSW_t^* = XPROD_t^* + XCO_t - XCON_t - XNEXP_t^*$$

- (9) Demand Supply Balance:

$$TIMP_t^* = TSW_t^* - WSTK_t^*$$

where

$SIMP^*$	= Per capita Soviet wheat imports,
$FOOD^*$	= Per capita Soviet usage of wheat for human food,
$FEED^*$	= Soviet usage of wheat for animal feed in m.m.t.,
$TIMP^*$	= Total per capita demand for wheat imports in m.m.t.,
$RIMP^*$	= Per capita wheat imports in the rest of the world,
$SPROD$	= Per capita Soviet wheat production in m.m.t.,
$SHARE$	= Soviet wheat production expressed as a share of total Soviet grain production,

INV	= Soviet cattle inventories in million head,
HAY	= Quantities of total succulent feed supplies in oat equivalent units,
RCON	= Per capita wheat usage, rest of the world; calculated as described in Appendix A,
RPROD	= Per capita wheat production, rest of world; calculated as described in Appendix A,
RSTK	= Per capita wheat carryover, rest of world; calculated as described in Appendix A,
XPROD*	= Wheat production within exporting regions in m.m.t.,
XNEXP*	= Net exports from five exporting regions in m.m.t.,
XCO	= Wheat carryover in exporting regions in m.m.t.,
XYLD	= Average wheat yield in exporting regions; calculated as described in Appendix A,
TSW*	= Total supply of wheat for exports in m.m.t.,
WP	= Estimated Soviet wheat import price in U.S. \$/m.t.,
SP	= Soviet rice import price in U.S.\$/m.t.; calculated as described in Appendix A,
WWP	= World wheat price in U.S.\$/m.t.; calculated as described in Appendix A,
INC	= Annual per capita Soviet income in rubles; calculated as described in Appendix A,
XCON	= Wheat usage within exporting regions in m.m.t.,
DY	= Dummy variable; 0 assigned to years before 1973 and 1 for 1973 and all other years.
WSTK*	= Net change in world wheat stocks in m.m.t.

In equation (1) Soviet wheat imports (SIMP) are postulated to be explained by domestic wheat usage, separated into wheat consumed for food (FOOD) and feed (FEED), as well as wheat production (SPROD), the Soviet import price for wheat (WP) and a dummy variable (DY).

Following Desai's example the variables for wheat production and the price of wheat imports are lagged one period to account for the difference between the time when the decision to import wheat is made and the actual time delivery is made. Usage variables are generally expected to have a positive relationship with import demand while price and production are expected to have negative effects on imports. However, in this model the usage variables are separated into two categories. The wheat used for human consumption is expected to have a positive relation with

import demand, following Kostecki's (1984, p. 202) explanation that high quality foreign wheat is bought to satisfy some of the domestic food requirements and thereby increase the availability of lower quality Soviet wheat for the livestock industry. In contrast, an inverse relation between feed wheat and wheat imports is supported by Desai (1982, p.317) who suggested that feed wheat would over time constitute a declining share of total feed grains as coarse grains were substituted for wheat. This could increase the availability of wheat for other uses such as human consumption and thereby result in an inverse relation between Soviet wheat imports and wheat used for feed purposes. This is considered likely to be a tenuous relation as at least some domestic Soviet wheat is generally considered not to be of a quality suitable for human consumption. The inclusion of lagged wheat production as an explanatory variable for Soviet wheat imports was supported by the comments made by Honma (1982). An inverse relation between wheat imports and wheat production would normally be anticipated, however, since wheat imports have been following an upward trend during the last part of the time frame examined in this study, the relationship could be positive. It was difficult to judge on *a priori* grounds the nature of the relationship between price and import demand given that from year to year other non-price influences are involved in national policy underlying wheat trading transactions. Nevertheless, it is worth noting that most wheat imported into the Soviet Union is of a quality suitable for human consumption. The Soviet import price was used as an explanatory variable rather than the average world wheat price.

The endogenous Soviet wheat usage variables of wheat for food and wheat for feed are examined in equations (2) and (3). Wheat consumed as human food is hypothesized to be influenced by the price paid for wheat imports (WP), income of Soviet citizens (INC) and the price of a substitute crop (SP). For this study rice was chosen as a substitute for wheat. It is expected that as income increases the demand for more food wheat should rise. Similarly, as the price of rice, a substitute good, decreases, the demand for wheat would decline as consumers moved to a more attractively priced starchy food for their diets. Wheat consumed as animal feed (FEED) is thought to be influenced by the quantity of wheat produced relative to total Soviet grain

production (SHARE). As the share of wheat production increases relative to total grain production, the amount of wheat fed would be expected to increase. Cattle inventories (INV) are also expected to have a positive relationship with the quantity of wheat consumed as animal feed. Substitute feed sources (HAY) are the quantity of total succulent feed supplies in oat equivalent units available in a given year. This included silage, green chop, potatoes, feed roots, melons and beet pulp as well as straw, hay and haylage. An increase in the use of roughages in livestock feeding practices is anticipated to have a negative impact on the demand for feed wheat.

The last demand side relationship of the model examines factors affecting wheat import demand for the remaining wheat importing nations in equation (4). Demand in ROW is postulated to be influenced by wheat usage (RCON), production (RPROD) and stock levels (RSTK) of this aggregated region as well as the world price of wheat. Due to the level of aggregation it was difficult to form *a priori* expectations for the relationships involved. However, in economic terms, lagged production and stock increases should reduce the demand for wheat imports. Increases in consumption figures, however, would be expected to have a positive effect on imports. Equation (5) describes an identity where total world wheat demand (TIMP), viewed in terms of imports, is equated to the sum of Soviet wheat import demand (SIMP) and wheat import demand for the rest of the world (RIMP).

Examination of the supply side of the model began with equation (6) which describes the behavior of the net wheat exports (XNEXP) from the five major wheat exporting regions. Postulated explanatory variables included lagged aggregate wheat production (XPROD) and lagged world wheat price (WWP). A positive relation between lagged production and exports is expected as increased production would increase the availability of wheat for exports the following year. It is anticipated that a positive relation would apply between world wheat price and net exports but the influence of other non-price influences between exporting countries and wheat buyers is expected to impinge on this relationship.

Wheat production by the major exporters is described by equation (7) where last year's yield (XYLD), lagged world wheat prices (WWP) and lagged wheat stocks (XCO) are proposed as

explanatory variables. While the previous year's wheat yield and world wheat price are anticipated to have a positive effect on the aggregate wheat production of these exporting regions, carryover is anticipated to deter production increases. There is reason to doubt the certainty of these *a priori* expectations due to variations in government policies amongst exporting countries and the differences in how and when production decisions are made within each country. Economic theory, however, would suggest that the world wheat price would have a positive relationship with production levels.

The identity in equation (8) is required to complete the supply side of the model. Using standard supply theory, total wheat supply (TSW) is identified as being the sum of carryover and production less net exports and wheat usage. Net exports are used to combine the two variables of imports and exports for the exporting regions. Equation (9) is specified to close the model. Total world wheat import demand (TIMP) is balanced with total world wheat exports (TSW) less the net change in world wheat stocks (WSTK).

Lines of Causality

Figure 3.1 represents the basic market components and lines of causality within this model as it has been described. Arrows indicate the lines of causality between the variables so an equation is symbolically represented by the arrows pointing to an endogenous variable. It is apparent that there is more than one endogenous variable in some equations. The appearance of more than one endogenous variable in an equation suggests that there is a feedback or indirect effect between the variables of the model. As explanatory endogenous variables may be correlated with the disturbance terms of individual structural equations, the model is expected to be simultaneous in nature.

To estimate the parameters of a simultaneous model an estimation technique capable of accounting for the simultaneous equation bias will be selected. However, prior to selection of the estimation technique it is necessary to determine if the model is identified and thereby to determine whether a unique solution to the parameters can be found.

Model Identification

The problem of whether the model was under, over or just identified was logically solved prior to estimation. Examination of each structural equation outlined above showed that by the order condition of identification all equations in the model were over-identified. While the order condition is necessary for identification it is not sufficient. The rank condition, which is both a necessary and sufficient condition for identification, confirmed that the model is identified and each equation is linearly independent of all other equations. The selection of estimation techniques is limited to those methods which can deal with simultaneous equation bias in over-identified equations.

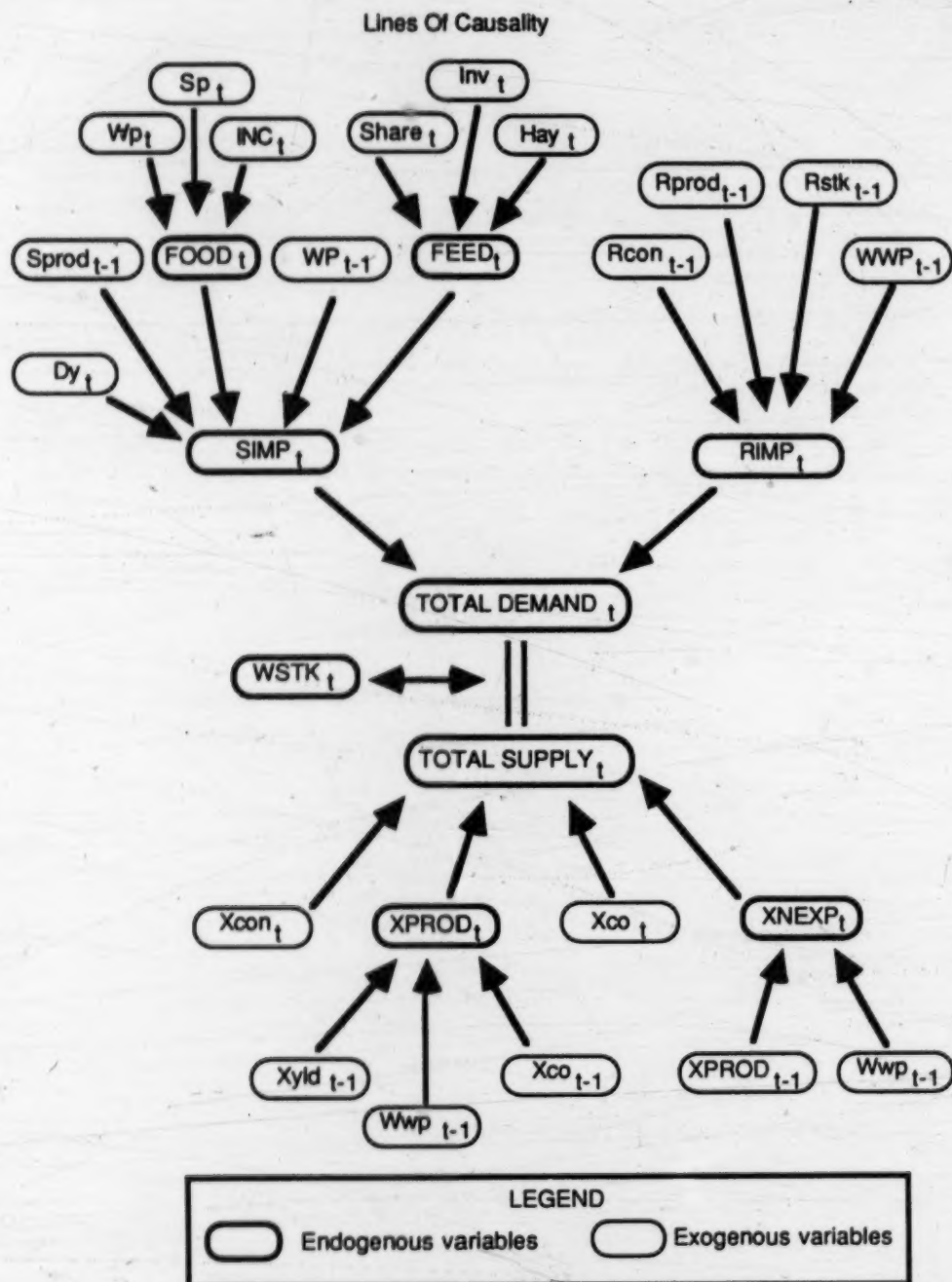


FIGURE 1

Estimation Technique

This section will discuss the selection of the appropriate estimation technique to be applied when estimating the parameters of a model of a type developed in this chapter. Intriligator (1978, pp. 373 - 375) cited three alternative approaches for estimating simultaneous equations based upon the amount of information from the system utilized in the estimation process. The first is the naive approach in which each equation in the system is estimated separately using the least squares technique. In this approach the set of explanatory variables contain only the endogenous and exogenous variables included in the equation being estimated. If the error terms in the different equations are not correlated, then this approach excludes the explanatory information included in the system but excluded from this equation. Moreover, there is no information as to which of the explanatory variables are endogenous and which are exogenous. The estimates achieved with this technique are generally considered to be biased and inconsistent because of the inclusion of endogenous variables in the set of explanatory variables and any correlation that could exist with the error terms.

The second approach, as outlined by Intriligator, is the limited information approach which also estimates one equation of the system at a time. This technique, however, distinguishes between explanatory endogenous variables and those exogenous variables included in the equation being estimated and also those included in the system outside this equation. By utilizing information about which variables are included in the other equations of the system but excluded from the equation being estimated, this technique recognizes the restrictions pertaining to the equation being estimated. Restrictions pertaining to the other equations are not recognized; hence the implication of the name limited information estimation technique.

The final estimation approach entails estimation of the entire system of simultaneous equations at once using all information available in each of the equations of the system and is thus called the full information approach. All the identifying restrictions about each equation would be used in the estimation of all the parameters in the system.

Parameters estimated by both the limited and full information estimation techniques have the property of consistency and asymptotic efficiency especially when referring to large samples. However, small sample properties vary between the estimation techniques. Intriligator (1978, p. 420) indicates that based on Monte Carlo studies the two stage least squares (2SLS) method performed best in the group of limited information estimators. This method was not affected by specification errors in other equations because it only deals with one equation at a time. Intriligator also noted that if the model and the variables are correctly specified, the full information approaches of three stage least squares (3SLS) and full information maximum likelihood (FIML), are the most desirable in terms of both bias and mean square error. However, these methods are more complicated and expensive to use and require a much larger sample size than limited information estimators.

Intriligator concluded that the Monte Carlo studies have shown that the 2SLS estimator is a good compromise choice among the group of various estimators. The 2SLS procedure avoided the bias and inconsistency of the naive approach while at the same time it avoided the sensitivity to specification and measurement errors of the full information techniques. If, however, correlations between disturbance terms in different equations are important while specification error and sample size are not, the 2SLS estimates may be improved upon by using a full information technique. Barring such special circumstances, Intriligator indicated that the 2SLS is both a reasonable and appropriate estimation technique in a simultaneous equation system.

As the model developed thus far is simultaneous in nature and is overidentified the choice has to be made between either limited information or full information estimation techniques. If the stochastic disturbance terms in the different structural equations are independent, then a limited information estimation technique that solves each equation separately, could be used. Choice of estimation technique also would have to consider the small sample size of this model and the likelihood of model specification error or measurement error in data concerning the Soviet Union.

In this model there is no reason to assume that the disturbance terms in the different structural equations are or are not independent. Therefore, either a limited or full information technique could be appropriate. However, the likelihood of specification errors due to the level of aggregation in some of the equations and the possibility of measurement error in Soviet data also have to be taken into consideration when selecting an appropriate estimation technique. Since either the limited or full estimation techniques have merit for estimating this model, it was decided that both methods will be employed. Results from both the limited information 2SLS technique and the full information 3SLS method are reported in the following chapter and evaluated for their individual merits in terms of the model in this study.

Data Sources and Limitations

Data for the endogenous and exogenous variables outlined above are collected from several different sources. The basic sources of data are the publications of the International Wheat Council (IWC), the Organization for Economic Cooperation and Development (OECD), the Food and Agriculture Organization of the United Nations (FAO), and the United States Department of Agriculture (USDA).

The data series selected has 25 data points for each variable representing 25 years of annual values. This encompasses the time period from 1960/61 to 1984/85. The examination of this particular time frame is of interest because it covers the time before and after the Soviet Union began regularly importing large quantities of wheat.

Data on wheat imports, which represent the quantity of wheat demanded, are collected from annual issues of F.A.O. Trade Yearbooks and converted to per capita terms by dividing with population figures as presented in various issues of the U.N. Statistical Yearbook. Both Soviet and ROW wheat imports are calculated in per capita terms to remove any linear relationships between variables. Total world and Soviet import data are both collected and the rest of the world imports are determined by subtracting Soviet imports from total world imports. Wheat export data

are collected from annual issues of World Wheat Statistics published by the IWC. While this data represents the combined exports from the five major exporting regions (Argentina, Australia, Canada, E.E.C., and the U.S.) during 1960/61 to 1984/85, the countries included in the European Economic Community varied over this time span. As a result the data collected reflects the inclusion of new member countries as they joined the European Common Market. Specifically, for the period 1960/61 to 1962/63 the E.E.C. export data includes only data from France. Between 1963/64 and 1967/68 the EEC data represents wheat exports from the six member states while the data from 1968/69 to 1980/81 contain the nine member states' wheat figures. Finally from 1981/81 1984/85 the data represents combined data from ten member states of the E.E.C.

The remaining supply side data sets for production, domestic usage or consumption, exports and carryover are also taken from World Wheat Statistics and compiled as described above to reflect the changing composition of the E.E.C. member states. All data series and sources as well as explanations of any calculations performed to construct a data series have been included in the appendices to this study.

CHAPTER IV

ESTIMATION RESULTS AND INTERPRETATIONS

Chapter Four presents and compares the results from all estimation techniques employed to estimate the model described in the previous chapter. This model, as developed, had nine equations. Of these, there are six behavioral equations that describe the dependent variables' responses and three equations for those identities that complete the feedback of the dependent variables. The six behavioral equations define stochastic relationships and, as such, include disturbance terms to represent any omitted explanatory variables, misspecification of the relationship or measurement error in the explanatory variables. The three remaining equations describe deterministic relationships that have neither stochastic disturbances or unknown parameters that need to be estimated. Together the nine equations determine the values of the nine current endogenous variables -- SIMP, FOOD, FEED, RIMP, XNEXP, XPROD, TIMP, TSW, WSTK -- given the values of the fifteen exogenous variables.

While the estimated parameters of the endogenous variables are determined within the model, the values of the exogenous variables are established by factors outside the sphere of influence of the world wheat market. Lagged variables are classified as predetermined because their value in the current period is known and could not be determined by the model. Other variables that are not lagged but also classified as predetermined are those economic variables set by Soviet government policy. Variables such as WP, SP, SHARE, INV and HAY were either price or policy oriented and subject to the overall central plans of the Soviet government. As the world wheat market would have no influence on these variables, they are classified as exogenous to the system.

All six behavioral equations are estimated together using an econometrics computer program entitled SHAZAM version 5.1, (White, 1985), on the University of Alberta computer. The following equations outline the initial results obtained when the two stage least squares (2SLS)

and three stage least squares (3SLS) estimation techniques are applied to the model developed in Chapter 3. The same set of data is used for both estimation techniques. The t-ratios are in parenthesis below the estimate for each coefficient and endogenous variables are designated by asterisks. The data set contains annual data representing twenty five years of information. Due to the lag structure of the model, estimates are only based on twenty four years of data. The results are as follows.

2SLS RESULTS:

$$(1a) \quad \widehat{SIMP}_t^* = 0.261 - 0.296 SP_{t-1} - 0.589 FOOD_t^* + 0.0002 FEED_t^* WP_{t-1} \\ R^2 = 0.76 \quad (2.1) \quad (-4.68) \quad (-0.70) \quad (0.51) \\ - 0.0003 + 0.024 DY_t \\ (-3.33) \quad (2.46)$$

$$(2a) \quad \widehat{FOOD}_t^* = 0.173 + 0.00007 WP_t - 0.00002 INC_t - 0.00003 SP_t \\ R^2 = 0.87 \quad (31.98) \quad (2.94) \quad (-10.73) \quad (-3.42)$$

$$(3a) \quad \widehat{FEED}_t^* = -118.64 + 93.448 SHARE_t + 0.991 INV_t + 0.014 HAY_t \\ R^2 = 0.74 \quad (-4.6) \quad (2.49) \quad (4.45) \quad (0.12)$$

$$(4a) \quad \widehat{RIMP}_t^* = 0.014 - 0.049 RSTK_{t-1} + 0.183 RCON_{t-1} - 0.115 RPROD_{t-1} \\ R^2 = 0.64 \quad (3.34) \quad (-0.39) \quad (5.39) \quad (-1.23) \\ - 0.000008 WWP_{t-1} \\ (-0.91)$$

$$(5a) \quad \widehat{XNEXP}_t^* = -18.312 + 0.548 XPROD_{t-1} + 0.045 WWP_{t-1} \\ R^2 = 0.77 \quad (-1.4) \quad (8.84) \quad (0.99)$$

$$(6a) \quad \widehat{XPROD}_t^* = -121.83 + 0.101 XYLD_{t-1} + 0.398 XCO_{t-1} + 0.109 WWP_{t-1} \\ R^2 = 0.72 \quad (-2.84) \quad (7.66) \quad (1.13) \quad (1.2)$$

3SLS RESULTS:

$$(1b) \quad \widehat{SIMP}_t^* = 0.289 - 0.256 SP_{t-1} - 0.899 FOOD_t^* + 0.00008 FEED_t^* \\ R^2 = 0.74 \quad (3.4) \quad (-5.87) \quad (-1.57) \quad (0.26) \\ - 0.0003 WP_{t-1} + 0.015 DY_t \\ (-3.76) \quad (2.18)$$

$$(2b) \quad \widehat{FOOD}_t^* = 0.171 + 0.00008 WP_t - 0.00002 INC_t - 0.00003 SP_t \\ R^2 = 0.87 \quad (35.11) \quad (4.15) \quad (-11.4) \quad (-4.71)$$

$$(3b) \quad \widehat{FEED}_t^* = -149.18 + 117.0 SHARE_t + 1.166 INV_t + 0.021 HAY_t \\ R^2 = 0.72 \quad (-7.14) \quad (3.84) \quad (6.48) \quad (0.23)$$

$$(4b) \quad \widehat{RIMP}_t^* = 0.017 - 0.0002 RSTK_{t-1} + 0.156 RCON_{t-1} - 0.154 RPROD_{t-1} \\ R^2 = 0.60 \quad (5.03) \quad (-0.002) \quad (6.79) \quad (-2.21) \\ - 0.000009 WWP_{t-1} \\ (-1.27)$$

$$(5b) \quad \widehat{XNEXP}_t = -14.325 + 0.489 XPROD_{t-1} + 0.059 WWP_{t-1}$$

$$R^2 = 0.75 \quad (-1.25) \quad (8.87) \quad (-1.59)$$

$$(6b) \quad \widehat{XPROD}_t = -119.23 + 0.096 XYLD_{t-1} + 0.555 XCO_{t-1} + 0.113 WWP_{t-1}$$

$$R^2 = 0.72 \quad (-3.32) \quad (8.68) \quad (2.17) \quad (1.42)$$

The overall explanatory power of each equation and magnitudes of the coefficients are generally similar between the two estimation techniques. Also, similar variables are significant in each equation. There are, however, some variables that are not, contrary to *a priori* reasoning, significant in either estimation technique. While different results from the two estimation techniques are expected at least to some extent, it is somewhat surprising that neither set of results supported *a priori* expectations for the behavior of Soviet wheat consumption variables. Since results here are only asymptotic, t-ratios exceeding the critical values of 2.58 (1%) and 1.96 (5%) indicate significance of the estimated coefficients of individual variables. On this basis the FOOD and FEED variables in equations (1a) and (1b) are clearly not significant. These expectations had underpinnings in economic theory and this caused some concern over possible misspecification of the model.

As the selection of these variables was not without merit, it was suspected that the basic hypotheses of employing them as explanatory variables were still correct but the nature of their postulated lagged relationships was not. To this end it was hypothesized that the Soviet wheat consumption variables should be lagged to reflect the difference in time when wheat was consumed and when it was actually imported. This placed consumption and production in the same time frame relative to wheat import deliveries. The model was estimated again using both estimation techniques with the Soviet consumption variables ($FOOD^*_t$ and $FEED^*_t$) lagged one time period relative to the Soviet import variable ($SIMP^*_t$). The results are as follows.

2SLS RESULTS: (with lagged $FOOD_{t-1}$ and $FEED_{t-1}$ variables).

$$(1c) \quad \widehat{SIMP}^*_t = 0.129 - 0.279 SPROD_{t-1} + 0.227 FOOD_{t-1} + 0.0005 FEED_{t-1}$$

$$R^2 = 0.76 \quad (1.13) \quad (-4.91) \quad (0.337) \quad (1.25)$$

$$\quad \quad \quad \quad \quad \quad \quad \quad \quad -0.0003 WP_{t-1} + 0.029 DY_t$$

$$\quad \quad \quad \quad \quad \quad \quad \quad \quad (-3.46) \quad (3.06)$$

$$(2c) \quad \widehat{FOOD}^*_t = 0.173 + 0.00007 WP_t - 0.00002 INC_t - 0.00003 SP_t$$

$$R^2 = 0.87 \quad (31.98) \quad (2.94) \quad (-10.73) \quad (-3.42)$$

$$(3c) \quad \widehat{FEED}_t = -118.64 + 93.448 \text{ SHARE}_t + 0.991 \text{ INV}_t + 0.014 \text{ HAY}_t$$

$$R^2 = 0.74 \quad (-4.6) \quad (2.49) \quad (4.45) \quad (0.12)$$

$$(4c) \quad \widehat{RIMP}_t = 0.014 - 0.049 \text{ RSTK}_{t-1} + 0.183 \text{ RCON}_{t-1} - 0.115 \text{ RPROD}_{t-1}$$

$$R^2 = 0.64 \quad (3.34) \quad (-0.39) \quad (5.39) \quad (-1.23)$$

$$-0.000008 \text{ WWP}_{t-1} \quad (-0.91)$$

$$(5c) \quad \widehat{XNEXP}_t = -18.312 + 0.548 \text{ XPROD}_{t-1} + 0.045 \text{ WWP}_{t-1}$$

$$R^2 = 0.77 \quad (-1.4) \quad (8.84) \quad (6.99)$$

$$(6c) \quad \widehat{XPROD}_t = -121.83 + 0.101 \text{ XYLD}_{t-1} + 0.398 \text{ XCO}_{t-1} + 0.109 \text{ WWP}_{t-1}$$

$$R^2 = 0.72 \quad (-2.84) \quad (7.66) \quad (1.13) \quad (1.2)$$

3SLS RESULTS: (with lagged FOOD_{t-1} and FEED_{t-1} variables).

$$(1d) \quad \widehat{SIMP}_t = 0.161 - 0.261 \text{ SPROD}_{t-1} + 0.008 \text{ FOOD}_{t-1} + 0.0004 \text{ FEED}_{t-1}$$

$$R^2 = 0.74 \quad (2.01) \quad (-6.43) \quad (0.02) \quad (1.2)$$

$$-0.0003 \text{ WP}_{t-1} + 0.022 \text{ DY}_t$$

$$(-4.32) \quad (3.03)$$

$$(2d) \quad \widehat{FOOD}_t = 0.171 + 0.00008 \text{ WP}_t - 0.00002 \text{ INC}_t - 0.00003 \text{ SP}_t$$

$$R^2 = 0.87 \quad (35.81) \quad (-4.16) \quad (-11.18) \quad (-5.15)$$

$$(3d) \quad \widehat{FEED}_t = -152.81 + 123.92 \text{ SHARE}_t + 1.152 \text{ INV}_t + 0.032 \text{ HAY}_t$$

$$R^2 = 0.72 \quad (-7.4) \quad (4.13) \quad (6.5) \quad (0.35)$$

$$(4d) \quad \widehat{RIMP}_t = 0.017 + 0.012 \text{ RSTK}_{t-1} + 0.157 \text{ RCON}_{t-1} - 0.164 \text{ RPROD}_{t-1}$$

$$R^2 = 0.59 \quad (5.01) \quad (0.13) \quad (6.83) \quad (-2.36)$$

$$-0.000008 \text{ WWP}_{t-1} \quad (-1.06)$$

$$(5d) \quad \widehat{XNEXP}_t = -14.576 + 0.496 \text{ XPROD}_{t-1} + 0.057 \text{ WWP}_{t-1}$$

$$R^2 = 0.76 \quad (-1.23) \quad (8.79) \quad (-1.43)$$

$$(6d) \quad \widehat{XPROD}_t = -118.68 + 0.095 \text{ XYLD}_{t-1} + 0.546 \text{ XCO}_{t-1} + 0.121 \text{ WWP}_{t-1}$$

$$R^2 = 0.72 \quad (-3.36) \quad (8.69) \quad (2.24) \quad (1.54)$$

While adding the lagged structure for the Soviet consumption variables did little to improve the significance of these variables, the level of significance for other variables was improved. For example, the policy variable contained in equations (1b) and (1c) is now significant at the 1% level compared to the 5% level previously. However, the 2SLS and 3SLS estimation results are still similar for the entire model and reveal a number of insignificant coefficients.

Lagging these two consumption variables has moved them from being classified as endogenous to being classified as predetermined. The model has almost become non-simultaneous with this change. There now remains only the WSTK variable as an endogenous

variable on the right hand side and it is only contained in the closure statement. This could partially explain the strong similarity between the results of the two estimation techniques. Indeed, the question is raised whether the near absence of endogenous variables in the set of explanatory variables has reduced the model to a system of equations that could be solved by the single equation OLS method. Before pursuing this question, the 2SLS and 3SLS results will be discussed.

In the Soviet wheat import equations (1c and 1d) the coefficients on each explanatory variable, with the exception of wheat for feed and food usage, are significant at the 1% level. The coefficients on the wheat for feed and food usage variables are not significant. The signs on all other coefficients of significant variables are as expected. Furthermore, in line with the earlier estimate by Desai (1982, p.320), the magnitude of the estimated coefficient on the lagged Soviet production variable is less than one. Desai determined that the Soviets did not use imports to make up entire shortfalls in domestic production. Rather, a shortfall was usually accompanied by other measures such as slaughtering of livestock, reduction of stocks or rationing. As a result, it was reasoned that the coefficient on the Soviet production variable should be negative and less than one given a linear relationship. This is the case in both the 2SLS and 3SLS results shown above.

Neither of the consumption variables, $FEED_{t-1}$ or $FOOD_{t-1}$, have significant coefficients indicating that the Soviet wheat imports are not directly affected by domestic wheat consumption, be it for human or animal feed purposes. The coefficients on the price of imported wheat in equations (1c) and (1d) are statistically significant at the 1% level and inversely related to the quantity of wheat imported.

The final variables in the Soviet import equations, (1c) and (1d), are the dummy variables, DY_t , which represent the changes in Soviet food policies apparent since 1971. The estimated coefficients on these variables are significant at the 1% level in both estimation techniques. In both instances the coefficients have positive signs suggesting the changes in Soviet food policies have had a positive impact upon wheat imports.

In equations (2c) and (2d) the per capita demand for wheat for human consumption within the Soviet Union is found to be negatively related to both consumer income (INC_t) and the price of a substitute good (SP_t) and positively related to its own price (WP_t). This is contrary to *a priori* expectations and suggests a specification error that could be attributed to either incorrect selection of variables or the inapplicability of consumer theory as described earlier to a centrally planned economy.

The number of livestock in the Soviet Union (INV_t), included in the third pair of equations, has a positive coefficient, indicating that the demand for wheat for animal feed varies directly with livestock inventories. A variable to account for the portion of wheat available for livestock feed relative to total grain production ($SHARE_t$) is significant at the 5 % level in the 2SLS results and the 1% level in the 3SLS results. In both estimation results $SHARE$ has a positive relationship with the demand for feed wheat. Quantities of alternate feed sources (HAY_t), such as hay and forage crops, have virtually no explanatory power in either equation. This is a surprising result and suggests that a dummy variable may be needed to account for a shift in Soviet government policy towards increasing the production of forage crops as a means of additional feed sources for the domestic livestock inventories. Such a policy variable was tried in equations (3c) and (3d) but as the results are not statistically significant they are not reported.

In equations (4c) and (4d) the demand for wheat imports in the remaining importing nations ($RIMP_t$) is positively related to lagged wheat consumption ($RCON_{t-1}$) in these regions. Lagged production ($RPROD_{t-1}$) has a negative relationship with $RIMP_t$ in the 3SLS estimation results while the world price of wheat (WWP_{t-1}) did not contribute to the overall explanatory power of the relationship. The estimated coefficient for lagged wheat stocks ($RSTK_{t-1}$) in the rest of the world's importing nations (equations 4c and 4d) is not statistically significant, a result contrary to *a priori* thought. However, this result is likely due to the level of aggregation involved in the data set for this particular regression relationship.

Supply side equations focus on net export volumes ($XNEXP^*_t$) and gross production ($XPROD^*_t$) within all five major exporting regions. Although net wheat export volumes are

positively related to aggregate production ($XPROD_{t-1}$) and significant at the 1% level, the world wheat price (WWP_{t-1}) is not statistically significant. Production has a greater impact upon net exports than does the world price of wheat which has no significant effect on the relationships expressed by equations (5c) and (5d).

Aggregate wheat production ($XPROD_t$) in the five exporting regions is described as a function of lagged yield ($XYLD_{t-1}$) and price (WWP_{t-1}) and lagged wheat stocks (XCO_{t-1}). Lagged yield is the only explanatory variable in equation (6c) that is significant while both lagged yield and carryover are significant in equation (6d). The dependent variable of wheat production varies directly with the lagged yield and wheat carryover stocks of the exporting regions.

Results from the two different estimation techniques are similar in the signs and magnitudes of the coefficients as well as when comparing the overall explanatory power of each equation. It is not clear which estimation technique yields the preferred estimates. In so far as there is more than one endogenous variable in some equations of the model, there exists the possibility of a simultaneous equation bias. A simultaneous estimation technique is therefore needed to estimate the model, but it is not clear whether a limited information or full information estimation technique is most appropriate based upon the results reported here. If the disturbance terms of the relations are independent, then the full information 3SLS estimation technique would reduce to the limited information 2SLS estimation technique. As there are only three to four variables in each equation, any excluded explanatory power has to be absorbed by the random disturbance term. It is possible, therefore, that the disturbance terms are contemporaneously correlated and the application of the 3SLS technique is a more complete estimation procedure to select for further analysis of Soviet wheat imports. Application of 2SLS under these circumstances would ignore part of the information included in the entire system and reduce the efficiency of the estimated coefficients.

To more fully assess the merit of both sets of results determined by the system estimation techniques, single equation tests of significance were undertaken. It was recognized, however, that such tests generally used in evaluating single equation estimation results are of questionable

value in systems of equations (White 1985, p.119). Despite this limitation, to gain some feel for any problems with multicollinearity or autocorrelation that may exist within the different equations, each equation is estimated again using the single equation ordinary least squares estimation technique. These single equation results may be used to indicate any problems there may be with the specification of the model. However, in view of the lack of simultaneity in the model in its current form, especially when single equation estimation techniques are used, the OLS results which are reported below simply mirror the 2SLS results presented previously.

OLS RESULTS: The t-ratios are in parentheses below each coefficient.

$$(1e) \quad \widehat{SIMP}_t = 0.129 - 0.279 SP_{t-1} + 0.227 FOOD_{t-1} + 0.0005 FEED_{t-1} - 0.0003 WP_{t-1} + 0.029 DY_t$$

(1.13) (-4.91) (0.337) (1.25) (-3.46) (3.06)

R² = 0.76 N = 24 F = 15.185 DW = 1.61

$$(2e) \quad \widehat{FOOD}_t = 0.173 + 0.00007 WP_t - 0.00002 INC_t - 0.00003 SP_t$$

(31.98) (2.94) (-10.73) (-3.42)

R² = 0.87 N = 24 F = 55.648 DW = 1.35

$$(3e) \quad \widehat{FEED}_t = -118.64 + 93.448 SHARE_t + 0.991 INV_t + 0.014 HAY_t$$

(-4.6) (2.49) (4.45) (0.12)

R² = 0.74 N = 24 F = 22.977 DW = 1.58

$$(4e) \quad \widehat{RIMP}_t = 0.014 - 0.049 RSTK_{t-1} + 0.183 RCON_{t-1} - 0.115 RPROD_{t-1} - 0.000008 WWP_{t-1}$$

(3.34) (-0.39) (5.39) (-1.23) (-0.91)

R² = 0.64 N = 24 F = 10.512 DW = 0.74

$$(5e) \quad \widehat{XNEXP}_t = -18.312 + 0.548 XPROD_{t-1} + 0.045 WWP_{t-1}$$

(-1.4) (8.84) (0.99)

R² = 0.77 N = 24 F = 39.365 DW = 0.60

$$(6e) \quad \widehat{XPROD}_t = -121.83 + 0.101 XYLD_{t-1} + 0.398 XCO_{t-1} + 0.109 WWP_{t-1}$$

(-2.84) (7.66) (1.13) (1.2)

R² = 0.72 N = 24 F = 20.923 DW = 1.11

Further examination is also made of variables by determining their correlation matrix.

These results reveal there is multicollinearity present between the lagged production and consumption variables of the rest of the world's importing regions. In equation (4e) the correlation coefficient between these variables is 10.512. Since multicollinearity in a regression can inflate the standard error, the t-ratio becomes a poor indicator of a variable's significance. The F statistic

therefore serves as a better indicator of the significance of the overall regression relations among variables of equation (4e). For this equation the calculated F statistic is 8.322, while the critical value for $F(0.95,4,21)$ is 2.84.

Since $F > F(0.95,4,21)$ we conclude there is a significant relationship between the dependent variable (RIMP) and the independent variables. Correction of the multicollinearity is not possible given the data sources, the need to maintain a linear relationship and the justification for keeping all the explanatory variables in the model based on the relationships as initially described. It was decided not to attempt to remedy the multicollinearity between the two variables because in the real world one would expect to have consumption and production variables moving together so the model, with its multicollinearity, may indeed be an accurate reflection of conditions in the world wheat market. Analysis of the F statistics for all other equations supported the existence of a significant regression relationship for each of the behavioral equations defined in the model when they are calculated with the ordinary least squares single equation technique.

Possibly because per capita data are used where appropriate, the problem of two variables moving together is not apparent in the remaining equations. There are problems, however, with autocorrelation as revealed by the Durbin Watson (DW) statistic presented below each equation. Intriligator (1978, p.159) points out that the problem of autocorrelation is frequent, if not typical, when using time series data, since in that case the stochastic disturbance terms may, in part, reflect variables not included explicitly in the model, which may change slowly over time. Thus, the stochastic disturbance term of one observation will be related to the stochastic disturbance terms of nearby observations.

For five independent variables, excluding the intercept, and twenty four observations, the lower and upper Durbin Watson critical values for 5% significance are 0.925 and 1.902, respectively. In reference to equation (1e), the calculated DW statistic falls between these upper and lower boundaries and is considered to be inconclusive in determining if first order autocorrelation exists. Equations (2e), (3e) and (6e) also show inconclusive results in evaluating

whether or not autocorrelation is present. It is stated by Intriligator (1978, p. 164), however, that the presence of first-order autocorrelation should be acknowledged when the DW statistic falls within the inconclusive range. Equations (4e) and (5e), with DW statistics less than one, all have positive first order autocorrelation present in their disturbance terms. The autocorrelation suggests a specification error in the model and that other explanatory variables should perhaps be included to reduce the serial correlation. But additional explanatory variables are not readily available, so the model will be used with the existing relationships.

Before proceeding with a discussion of the implications of the estimated model, the three sets of results are compared to determine the most suitable estimation technique for the objectives of this study. Given the nature of the set of explanatory variables, the results from the OLS, 2SLS and 3SLS estimation techniques are very similar. The 3SLS and 2SLS results have coefficients with exactly the same signs and of similar magnitudes for most of the variables. The levels of significance are also similar in most cases, although estimates from the 3SLS technique have slightly larger t-ratios as a general rule. By contrast, each equation estimated by the 2SLS has an R^2 that is a few points greater than the R^2 of the comparable 3SLS equation. An examination of the 2SLS and OLS results reveals that the coefficients of the two estimation techniques not only have the same signs but also have, in virtually every instance, the same estimated value. Furthermore the R^2 values and t-ratios are exactly the same in both the OLS and 2SLS estimation results. This result is expected, however, since lagging the two consumption variables, FEED and FOOD, removed all but one endogenous variable from the right hand side of the model. The model has, in essence, become non-simultaneous in so far as the structural equations are concerned. The only remaining endogenous variable in the set of explanatory variables, WSTK, is contained in the closure statement.

At the end of Chapter 3 the merits of each estimation technique were discussed in detail. That description indicated that a single equation estimation technique, such as OLS, only used the information contained in the equation being estimated. If the set of explanatory variables contained endogenous variables, this technique would result in biased and inconsistent

estimates of the coefficients. The limited information estimation techniques such as 2SLS, however, has a much larger set of explanatory variables because it utilizes information about which variables were included in the other equations of the system but excluded from the equation being estimated. No recognition, however, was made of any restrictions on the other equations. This last attribute is acknowledged in full information estimation techniques such as 3SLS. Both the limited and full information estimation techniques can calculate consistent estimates of the coefficients when there is simultaneity present in the model.

In this study the sample size is small and under these circumstances the limited information estimation technique of 2SLS is more suitable. Also, the 2SLS technique is not as adversely affected by specification errors as the 3SLS technique. We suspect from the presence of autocorrelation in the OLS results that there is a specification error of some magnitude. Furthermore, the nature of the data is such that a measurement error is highly probable. The similarity between the 2SLS and OLS results confirms that there is no simultaneity bias present in the structural equations of the model. Indeed the presence of the one endogenous variable on the right hand side in the closure statement appears to be the only source for potential simultaneity in the model. Based upon the sample size, the possible presence of specification errors and the likelihood of measurement errors in the data it was decided to base further discussions on the estimation results obtained from the limited information 2SLS estimation technique although it is recognized that the OLS results would have also been suitable.

Implications of the Results

Analysis of the results begins with an examination of the relevant elasticities. These are elasticities calculated at the mean and based on the 2SLS estimation results. According to these estimates, the USSR price elasticity of demand for wheat imports is -1.7973 as calculated from a coefficient with a t-ratio of 3.46. Jones, et al. (1986, p.100) stated that agricultural imports from Western countries into Central Planned Economies are generally expected to be price inelastic although empirical evidence has shown wide variations. The cited reasons for this inelasticity

included an unwillingness to substitute goods in consumption once consumption targets were set and the way in which domestic prices are insulated from world market prices. Also, production plans were unlikely to be altered by variations in world market prices. Empirical evidence, Jones concluded, is not conclusive as work to date on agricultural imports in Centrally Planned Economies has yielded wide variations regarding price response. Import demand elasticity estimates reported by Jones et al. (1986, p.101) ranged from -1.50 for a corn import elasticity of demand to -2.12 as the elasticity of demand for Soviet grain imports.

The elasticity of Soviet wheat imports with respect to Soviet wheat production is more responsive with an estimated elasticity calculated at the means of the variables of -2.7637 from a coefficient significant at the 1% level. This suggested that Soviet decision makers would be responsive to increasing imports to meet domestic wheat needs when production shortfalls occurred and vice versa. The quantity of imports demanded was more responsive to changes in domestic production than to changes in the import price of wheat.

The elasticity of the quantity of wheat demanded relative to the price of a substitute commodity such as rice is very inelastic and negative with a value of -0.0815 based on an estimated coefficient significant at the 1% level. Economic theory suggests that substitute goods should have positive cross elasticities, contrary to the results reported in equation 2. Similarly, the income elasticity, calculated as -0.2242 on a coefficient with a t-ratio of 10.73, suggests that wheat is an inferior good that will tend to decrease in consumption when incomes rise. These factors need to be evaluated in terms of the economic environment present in the Soviet Union. In such an economy, the quantity of goods available to consumers is often restricted or rationed. Prices for staple items are not increased in response to increased demand and consumers, whose incomes have risen over time, are faced with the same quantities but higher disposable incomes. The OECD has indeed reported that while Soviet incomes have risen over time the domestic production of staple food items has not always kept pace. As a result the market place does not respond with increased supplies and consumers must face line ups or bare shelves. In these surroundings, the calculated values of income or cross elasticities of demand will reflect the

feature that prices of products are not free to move in response to changes in the quantities demanded. The interpretation of such elasticities must therefore be done with caution.

To evaluate the validity of the simulation of the model in this study, the predicted values of the individual endogenous variables, determined from the estimated equations of the model, were compared to their corresponding data values over the entire time span of the model. The quantitative measure used for this was the RMS (root-mean-square) simulation error which is defined as

$$\text{RMS error} = \sqrt{\frac{1}{T} \sum_{t=1}^T (\hat{Y}_t - Y_t)^2}$$

where $\hat{Y}_t$ = the predicted value of the endogenous variable,

Y_t = the actual value of the endogenous variable,

T = the number of time periods in the model.

The values calculated to assess the magnitude of error compared to the average size of the variable in question are presented below.

Table 4.1

RMS Errors and Ratios to Mean Values for Endogenous Variables

<u>Variable</u>	<u>Mean</u>	<u>RMS Error</u>	<u>RMS Error / Mean</u>
SIMPPC	0.0346	0.01350	39.02%
FOODPC	0.1418	0.00330	2.33%
FEED	30.5830	6.77519	22.15%
RIMPPC	0.0184	0.00183	9.94%
NEXP	57.0150	9.81078	17.21%
XPROD	126.1100	18.39647	14.59%
TIMP	0.0529	0.01435	27.13%
TSW	48.8160	21.06159	43.14%

The RMS errors as a percentage of the mean value for each variable indicate how much the estimated value varies from the actual value over the time span modelled. These values showed that the Soviet wheat usage for food purposes was well simulated with a small RMS error compared with its mean value. The other consumption variable also showed a small RMS error.

Honma reported similar findings and suggested consumption does not vary much over time so all consumption variables are likely to show small RMS errors (Honma, 1982, p.115).

Soviet wheat imports were not as well simulated as the consumption variables with the RMS error being 39 percent of the mean import value. The actual Soviet wheat import quantities showed wide fluctuations in the twenty five year time period of the model. Per-capita imports ranged from 0.000342 metric tons to a high of 0.09916 metric tons, or in aggregate terms, from 75,800 metric tons in 1962 to a record high wheat import volume of 27,279,369 metric tons in 1984 (F.A.O. Trade Yearbook, various issues). Honma (1982, p.113), who studied ten different wheat importing regions, also found the USSR to have the largest RMS error as a percentage of mean of all ten importing regions. The RMS error to mean percentages from his study ranged from 3.77 per cent for Japan, a country long recognized as a importer of consistent volumes in world trade, to 59.90 per cent for the USSR. Differences between the results of this study and Honma's may be attributed to the different time spans employed in each study. Longer time frames might have a smoothing effect on the data resulting in this study displaying a lower RMS error to mean ratio. Differences may also be attributed to the differences in the two models used to estimate the coefficients.

Total imports for both the rest of the world and aggregate world showed smaller RMS error to mean ratios than did the Soviet import figures. This suggested the import volumes were generally better simulated for regions other than the Soviet Union. A comparison of the absolute range of import volumes as a percentage of record high import volumes revealed the rest of the world to have the least variation in import volumes with total world imports a close second. Soviet wheat import volumes, however, show fluctuations of two and a half orders of magnitude. Such variability contributes to the difficulty of modelling this variable as is implied by the RMS error to mean percentages displayed above.

On the supply side, wheat exports (NEXP) and production (XPROD) were generally well simulated relative to the total supply of wheat variable (TSW). The RMS error to mean ratio for wheat production in the exporting regions was marginally lower than the export value, a result also

found by Honma (1982, p.112) for each of the five exporting regions examined. Both these variables had RMS error to mean ratios less than half the value calculated for the total supply of wheat variable. This variable was not well simulated relative to the other endogenous variables in the model.

CHAPTER V

SUMMARY AND CONCLUSIONS

Summary

The central purpose of this study was to examine the demand for wheat imports of one of the world's major wheat buyers. This was pursued through the development of an econometric model that used variables and economic relationships that reflected Soviet wheat import behavior. The study commenced with a general review of the world wheat economy and specific elements of the Soviet wheat sector. Also, studies of a related nature in both subject matter and econometric modelling techniques were reviewed to determine the variables and econometric applications that appeared to be most appropriate.

Background information on the structure of the world wheat economy and Soviet import patterns indicated that while today there are few wheat exporters and many importers, the roles of the countries involved have changed over time. Most notably, the Soviet Union changed from being a net exporter of wheat in the 1960's to the role of a consistent wheat importer in the early 1970's. During this time the Central Planners of the Soviet Union made significant changes to internal policies pertaining to domestic production and consumption of meat and dairy products.

Selection of the variables and formulation of the economic relationships were based upon the structural factors determined from the review of world and Soviet wheat economies. As a result, the demand side variables selected for the Soviet Union were lagged domestic consumption disaggregated into demand for livestock feed and human food purposes, lagged domestic production in lieu of inventory values, the lagged import price of wheat and a dummy variable to reflect the change in Soviet domestic policies. Feed usage was hypothesized to be a function of total wheat production as a portion of all grain production, livestock inventories and production of alternate feeds. Food usage was postulated to be a function of the import price of wheat, consumer income and the import price of a substitute starchy food such as rice. Demand

side variables hypothesized to explain the combined behavior of all other wheat importing regions were lagged wheat stocks, consumption, production and the world price of wheat.

To describe the behavior of the supply side of the world wheat market, the five major exporting regions were viewed as one supplier. Data on their aggregate wheat production, yields and stocks were combined with the average world wheat price as variables explaining the supply of wheat available for the world wheat market. The five exporting regions identified were the U.S., Canada, Australia, Argentina and the E.E.C. member countries with the make up of the E.E.C changing over the time span of this study.

The variables and their relationships were combined in a model of nine equations. These were six behavioral equations and three identity equations to complete the feedback of the dependent variables. Together, the nine equations determined the values of the nine endogenous variables given the values of the fifteen exogenous variables. Due to the simultaneous nature of the relationships involved, the model was initially solved using both 2SLS and 3SLS estimation techniques. The results of both estimation techniques were similar in the signs and magnitude of the estimated coefficients as well as in the explanatory power of each equation. This suggested there may be very little simultaneity present in the model. Evidence of the absence of simultaneous equation bias was provided by OLS estimation results which proved to be identical to the 2SLS estimations. It was recognized that given the OLS and 2SLS estimations were identical the OLS results would have been suitable for discussion of model results. Finally, since the model was over-identified, the sample size small, the likelihood of measurement error great and the presence of specification errors evident, the 2SLS estimation technique was selected as the most suitable approach for solving this model.

Several of the estimated parameters in the first and third equations that described Soviet import demand were of similar magnitude and sign to the estimates from previous studies. For example, Desai's work (1982), which focused on combined grain imports, concluded that lagged grain production was a significant factor in determining grain imports and had a negative relationship with the volume of grain imported. Also, Desai's dummy variable, which was included

to explain any structural shifts that could be associated with changes in Soviet policy, and the livestock inventories variable were both strongly significant and had a positive relationship with the volumes of Soviet grain imports. These features were similar to the results of this study which focused only on wheat imports. The present study also found the lagged import price of wheat to be strongly significant and inversely related to wheat imports. By contrast, Desai assumed imports to be influenced by considerations other than price and did not use price as an explanatory variable.

The results of this study can be compared with the Soviet wheat import section of Masayoshi Honma's study (1982). In Honma's study the estimated coefficient on wheat import price and inventory levels were both significant and had an inverse relation with import volumes, while wheat import volumes varied directly with a dummy variable used to describe the shift in Soviet policies. The current study showed similar results although it should be noted that a lagged production variable was used in the present study in lieu of an inventory variable. Where Honma's results differ from this study are in terms of the income variable. Honma found this variable not to be significantly associated with the quantity of wheat consumed for human food while here it was found to be strongly significant but with a sign suggesting that wheat is an inferior good.

An aggregate equation to describe the wheat demand by all other importing regions was included to complete the world wheat demand side of the model. Production and consumption were the only two variables that had any significant explanatory power and production was only significant at a very low level. The world wheat price and lagged wheat stocks variables were both strongly insignificant. Given the level of aggregation these equations give only a very broad interpretation of the import behavior of the other major importing regions.

The supply side equation estimated coefficients supported *a priori* reasoning in so far as the lagged production variable was positively related to wheat export volumes. The estimated coefficients on most other variables, however, were insignificant and overall the estimations for

these equations were considered to be poor. Part of the problem is likely due to the level of aggregation and the possibility of specification errors in each equation.

Conclusions

First, this study suggests that for this particular model a simple single equation estimation technique had as much merit as the more elaborate simultaneous equation techniques. This is not to say that the additional variables used in the extra equations and/or relationships were of no benefit. Indeed, it would appear that the relationships expressed in equations 2 and 3 do successfully expand those described by either Honma or Desai and give an indication of internal impacts upon Soviet wheat consumption.

However, given that the model was finally described with lagged Soviet consumption variables, it had little simultaneity. This suggested that several single equations could have been as effective in estimating Soviet import demand relationships. Based upon the OLS estimates, the quasi-elaborate model developed in this study added very little to the basic Soviet wheat demand relationships. It is likely that this arises since all the other equations were aggregated to such a high level that they had little explanatory power. Fortunately, the level of simultaneity in the model was low, so that any possible misspecification errors in equations 4, 5 and 6 did not appear to have any negative impact on the Soviet demand equations.

Second, the results of equation 1 suggest that, as a major wheat importing nation, the Soviet Union does appear to allow the import price of wheat to sway purchasing decisions. This was not suggested for the other importing and exporting regions of the world where the price variables tended to have insignificant coefficients. Estimated parameters in equation 1 also indicated that the Soviet Union was not responsive to maintaining wheat import volumes for either human or animal consumption needs per se. However, the change in Soviet policies towards importing grain when needed did appear to have a strong and positive impact upon wheat imports. This is evident from the results for the first equation where a dummy variable was

included to measure any structural shift to this effect. Lagged Soviet wheat production was also found to significantly affect the level of wheat imports in an inverse manner.

Equations 2 and 3 described the domestic consumption of wheat for either human food or animal feed. Wheat consumed for human food was inversely related to per capita Soviet income. Also, the income elasticity of demand showed wheat to be an inferior good in terms of the preference patterns of consumers. Over the past two decades consumer prices have been virtually constant as the availability of meat and dairy products have increased. In the same two decades wages have doubled. It appears that the relative changes in wheat consumption are inversely related to relative changes in Soviet per capita income. Feed wheat consumption within the Soviet Union increased with livestock inventories and the relative share of total grain production that wheat comprised.

Overall, one would conclude that an ad hoc model such as the one developed in this study can, at best, only suggest broad implications for the behavior of a single participant in a large world market. There is an inherent problem with research conducted on the perceived relationships between variables suggested by other studies because there is no real theory of why some coefficients are significant and others are not.

Recommendations

Since the primary objective for the development of this model was to examine Soviet import behavior for wheat, the rest of the world import equation (equation 4) and supply side equations (equations 5 and 6) did not contain the same level of detail as did the Soviet import and usage equations (equation 1, 2 and 3). Further development of equation 4 might provide insights into factors affecting wheat import behavior in other major importing regions. This might be accomplished by disaggregating the importing regions into developed countries, developing countries and other centrally planned economies. Similarly, separating the exporting regions could provide an opportunity to examine shifts in trading patterns between specific exporting countries and the Soviet Union. While the first of these two recommendations may improve the

explanatory power of equation 4, the second could have merit in revealing how internal Soviet import decisions alter external Soviet buying patterns. That is to say, if internal Soviet policies do affect Soviet gross wheat imports, as this study suggests, would such policies also affect where the Soviets turn for their supplies on the world market? Such a study would involve an expansion of this model and likely require a simultaneous equation estimation technique to deal with the inherent simultaneous relationship between the variables.

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APPENDIX A: VARIABLE DESCRIPTIONS AND SOURCES

TABLE A:1

Descriptions and Sources of Variables

Variable	Description and Sources
SIMP	Per capita Soviet wheat imports calculated by dividing total Soviet wheat imports by total Soviet population. Wheat import figures from <u>F.A.O. Trade Yearbooks</u> and population data from <u>U.N. Statistical Yearbooks</u> .
FOOD	Soviet wheat consumed for human food in per capita terms. Food consumption figures for the period of 1971/72 to 1984/85 from USDA, Agricultural Situation, <u>Review of 1978 and Outlook for 1979</u> , USSR, WAS-18, April, 1979 and USDA, Economic Research Service, <u>USSR Situation and Outlook Report</u> , RS-86-3, May, 1986. Values from 1960/61 to 1970/71 estimated from the share of all grains consumed for human food. Data on all grain consumed for human food from USDA Agricultural Situation, <u>Review of 1978 and Outlook for 1979</u> , USSR, WAS-18.
FEED	Soviet wheat used for animal feed in millions of metric tons. Data collected from OECD, <u>Prospects for Soviet Agricultural Production and Trade</u> , 1983; USDA, Agricultural Situation, <u>Review of 1978 and Outlook for 1979</u> , USSR, WAS-18, April, 1979; and USDA, Economic Research Service, <u>USSR Situation and Outlook Report</u> , RS-86-3, May, 1986.
TIMP	Per capita total world wheat imports in million metric tons calculated as the combination of RIMP and SIMP discribed earlier.
RIMP	Rest of the world wheat imports in per capita terms. Calculated as the residual of total world wheat imports (TIMP) less both Soviet imports (SIMP) and the imports of exporting regions divided by world population less both the Soviet Union and exporting countries' populations. <u>U.N. Statistical Yearbooks</u> were the source of population figures. Wheat import values were from <u>F.A.O. Trade Yearbooks</u> for

TIMP and SIMP while exporting regions imports were collected from the International Wheat Council's, World Wheat Statistics.

SPROD	Per capita Soviet wheat production calculated by dividing Soviet wheat production as published in the International Wheat Council's <u>World Wheat Statistics</u> and divided by Soviet population data collected from <u>U. N. Statistical Yearbooks</u> .
SHARE	Soviet wheat production expressed as a share of total Soviet grain production in absolute terms; not per capita. Wheat production (SPROD) as above and total grain production as presented by M. M.Kostecki (1984) Table 10.2.
INV	Soviet cattle inventories in million of head as recorded on January 1 of each year and reported in <u>Spravochnik ekonomista kolkhoza i sovkhoza</u> with reprints in Michael Zahn (1979) Table 4. More recent years are from the USDA publications <u>USSR Outlook and Situation Report</u> , issues RS-84-4, May, 1984 and RS-86-3, May, 1986.
HAY	Quantity of total succulent feed supplies in millions of tons of oat equivalent units as presented in OECD, <u>Prospects for Soviet Agricultural Production and Trade</u> , 1983, Table XII and USDA, <u>USSR Outlook and Situation Report</u> , RS-85-4, April, 1985. Succulents have been described as corn silage and green chop, other silage, potatoes, feed roots and melons, and beet pulp.
RCON	Calculated as total world wheat consumption less total wheat consumption in both the Soviet Union and the five major exporting regions. This variable was used in per capita terms with the population as described in RIMP above. World wheat consumption data was from USDA, <u>Wheat Situation</u> ; Soviet wheat total consumption was estimated from 1960/61 to 1970/71 while USDA, <u>USSR Situation and Outlook Report</u> , RS-86-3, May, 1986 and USDA Agricultural Situation, <u>Review of 1978 and Outlook for 1979 USSR</u> , WAS-18, April, 1979 provided actual values for the years after 1970/71; and wheat consumption in the exporting regions was taken from the IWC, <u>World Wheat Statistics</u> .
RPROD	Calculated as total world wheat production less total wheat consumption in both the Soviet Union and the five major exporting regions. This variable was used in

per capita terms with the population as described in RIMP above. World wheat production data was from IWC, World Wheat Statistics; Soviet wheat total production was as described in SPROD above; and wheat production in the exporting regions was taken from the IWC, World Wheat Statistics.

RSTK

Calculated as total world wheat carryover less total wheat carryover in the five major exporting regions. This variable was used in per capita terms with the population as described in RIMP above. World wheat carryover data was from USDA, Wheat Situation; and wheat carryover in the exporting regions was taken from the IWC, World Wheat Statistics. As there were no published statistics on the Soviet wheat carryover, these values are estimated without a Soviet wheat stock figure.

XPROD

Exporting regions wheat production data in million of metric tons as published in the IWC's World Wheat Statistics. Composition of the exporting regions changed over the time span of the model because of the changing participants of the EEC. These countries are detailed in the notes to Appendix C, Table C.1.

XNEXP

Net wheat exports of the exporting regions in million of metric tons. Calculated as total exports minus imports for the countries involved. Data collected from the IWC's World Wheat Statistics. Composition of the countries involved detailed in Appendix C, Table C.1.

XCO

Total carryover of wheat stocks in the exporting regions in million of metric tons. Data collected from the IWC's World Wheat Statistics. Composition of the countries involved detailed in Appendix C, Table C.1.

XYLD

Average yield in exporting regions in kg/hac. Calculated as total wheat production divided by total area. Data collected from the IWC's World Wheat Statistics. Composition of the countries involved detailed in Appendix C, Table C.1.

XCON

Exporting regions wheat consumption data in million of metric tons as published in the IWC's World Wheat Statistics. Composition of the exporting regions changed over the time span of the model because of the changing participants in the EEC. These countries are detailed in the notes to Appendix C, Table C.1.

WP	Soviet wheat import price in U.S. \$ per metric ton. Estimated from <u>F.A.O. Trade Yearbook</u> data on total volumes and value of Soviet wheat imports by dividing total value of wheat imports by the total volume of imports.
TSW	Total supply of wheat in the world wheat market in million of metric tons. Calculated as the exporting regions wheat production plus carryover less consumption and net exports. Data collected from the IWC's <u>World Wheat Statistics</u> . Composition of the countries involved detailed in Appendix C, Table C.1.
SP	Soviet rice import price in U.S. \$ per metric ton. Estimated from <u>F.A.O. Trade Yearbook</u> data on total volumes and value of Soviet rice imports by dividing total value of rice imports by the total volume of rice imports.
WWP	World wheat import price in U.S. \$ per metric ton. Estimated from <u>F.A.O. Trade Yearbook</u> data on total volumes and value of world wheat imports by dividing total value of world wheat imports by the total volume of imports.
INC	Annual Soviet income in rubles based upon Table 29, page 46 in <u>USSR Agricultural Situation: Review of 1976 and Outlook for 1977</u> , USDA Economic Research Service, FAE Report No. 132, April, 1977. This table contains average monthly wages and salaries (excluding collective farmer incomes) for 1960 to 1976. Incomes for post 1976 were estimated from annual percentage changes in Soviet income figures published in Appendix B, Table B.3 of <u>Economic Survey of Europe in 1984-85</u> . Annual data estimated as monthly data multiplied by 12.
WSTK	World wheat stocks measured in metric tons as published in <u>Wheat Situation</u> , USDA, Economic Research Service, various issues.

APPENDIX B: DEMAND SIDE VARIABLES

TABLE B:1

Soviet Wheat Data Series
(in '000 metric tons)

Year	Production	Imports	Food Usage	Feed Usage	Total Consumption
1960/61	64,299	121.500	32,000	10,000	65,562
1961/62	66,486	678.400	34,000	13,000	71,819
1962/63	70,778	75.800	37,000	8,000	69,324
1963/64	49,668	3,437.500	36,000	3,000	61,844
1964/65	74,399	8,631.400	35,000	9,000	69,750
1965/66	59,686	6,776.600	34,000	20,000	78,019
1966/67	100,499	8,030.600	34,000	16,000	78,819
1967/68	77,300	2,122.000	34,000	20,000	80,091
1968/69	93,393	1,705.500	34,000	27,000	87,983
1969/70	79,917	417.800	35,000	33,000	93,399
1970/71	99,664	2,205.773	35,000	39,000	101,721
1971/72	98,760	2,688.087	35,000	36,000	94,000
1972/73	85,993	8,481.142	35,000	41,000	99,000
1973/74	109,784	15,625.867	34,000	30,000	95,000
1974/75	83,913	3,145.464	34,000	34,000	93,000
1975/76	66,224	9,616.681	35,000	30,000	88,000
1976/77	96,882	7,214.024	35,000	28,000	93,000
1977/78	92,161	7,142.293	35,000	44,000	109,000
1978/79	120,936	9,363.474	35,000	43,000	107,000
1979/80	90,207	10,349.421	35,000	53,000	115,000
1980/81	98,182	16,032.045	36,000	48,000	115,000
1981/82	80,000	18,677.758	36,000	42,000	102,000
1982/83	85,000	22,159.720	36,000	45,000	106,000
1983/84	80,000	22,248.320	36,000	36,000	97,000
1984/85	75,000	27,279.360	36,000	36,000	96,000

Sources: World Wheat Statistics, I.W.C., various issues.
Trade Yearbook, F.A.O., various issues.
Prospects for Soviet Agricultural Production and Trade, O.E.C.D., 1984.
USSR Situation and Outlook Reports, USDA, various issues.

TABLE B:2
World Wheat Data Series
(in million metric tons)

Year	Production	Imports	Consumption	Stocks
1960/61	241.0	19.32	234.80	81.80
1961/62	227.0	23.02	236.30	70.20
1962/63	258.0	42.20	248.10	74.00
1963/64	241.0	48.28	240.00	67.80
1964/65	276.0	56.34	262.00	76.20
1965/66	265.0	65.70	281.50	55.30
1966/67	311.0	71.90	279.90	82.10
1967/68	300.0	61.94	289.10	90.60
1968/69	332.0	61.89	306.40	115.00
1969/70	315.0	58.19	327.30	97.80
1970/71	319.0	54.92	327.20	74.30
1971/72	354.0	57.59	344.30	81.00
1972/73	348.0	61.07	361.80	62.60
1973/74	376.0	76.70	365.60	70.20
1974/75	364.0	66.43	366.60	63.80
1975/76	359.0	72.71	356.30	64.10
1976/77	425.0	72.20	385.90	99.80
1977/78	386.0	71.18	399.40	84.20
1978/79	451.0	80.58	430.20	100.80
1979/80	429.0	85.92	444.30	81.00
1980/81	445.0	97.30	445.70	78.20
1981/82	454.0	103.58	441.50	85.10
1982/83	483.0	108.63	467.90	96.40
1983/84	496.9	106.68	486.25	101.06
1984/85	521.0	115.60	495.09	125.74

Sources: World Wheat Statistics, I.W.C., various issues.
Trade Yearbook, F.A.O., various issues.
Wheat Situation, USDA, Economic Research Service, various issues.

TABLE B:3

Rest of the World's Wheat Data Series
(in '000 metric tons)

Year	Production	Imports	Consumption	Stocks
1960/61	103,231	18,456.9	133,533	23,484
1961/62	97,797	21,740.3	129,778	22,080
1962/63	114,639	41,293.2	144,111	23,838
1963/64	97,984	40,617.8	125,109	21,857
1964/65	99,744	44,128.7	136,615	30,404
1965/66	108,216	54,659.3	145,358	21,918
1966/67	106,998	59,411.6	144,350	46,726
1967/68	119,332	56,140.3	152,604	47,154
1968/69	121,246	51,246.5	149,000	52,751
1969/70	124,282	49,237.8	161,334	32,490
1970/71	125,912	42,690.1	162,907	23,535
1971/72	142,694	48,099.6	174,585	32,094
1972/73	149,580	45,424.1	183,785	35,072
1973/74	143,764	55,474.0	198,097	44,095
1974/75	155,644	57,421.4	203,029	33,610
1975/76	159,696	55,910.6	198,014	26,064
1976/77	184,600	61,008.0	223,437	43,432
1977/78	165,540	58,478.1	215,523	30,845
1978/79	187,049	66,106.7	248,146	44,614
1979/80	192,891	70,743.0	253,321	32,219
1980/81	192,065	76,654.4	254,037	31,573
1981/82	194,954	79,774.4	258,959	31,052
1982/83	212,417	82,781.4	278,990	30,648
1983/84	230,111	81,204.2	296,981	37,066
1984/85	246,296	84,904.5	302,940	53,093

Sources: As per Tables B.1 and B.2.

APPENDIX C: SUPPLY SIDE VARIABLES

TABLE C:1

Exporting Regions Wheat Data Series
(in '000 metric ton)

Year	Production	Yield (kg/ha)	Import	Consumption	Exports	Stocks
60/61	73,470	1658	754	35,705	36,688	58,316
61/62	62,717	1386	601	34,703	38,811	48,120
62/63	72,583	1698	835	34,665	37,635	50,162
63/64	93,348	1810	4,220	53,047	53,653	45,943
64/65	101,857	1813	3,578	55,635	49,947	45,796
65/66	97,098	1807	4,269	58,123	55,658	33,382
66/67	103,503	1852	4,461	56,731	49,485	35,374
67/68	103,368	1705	3,675	56,405	42,566	43,446
68/69	117,361	1883	8,935	69,417	38,117	62,249
69/70	110,801	2015	8,536	72,567	43,709	65,310
70/71	93,424	2133	10,027	72,572	45,423	50,765
71/72	112,546	2265	6,799	75,715	45,489	48,906
72/73	112,427	2186	7,161	79,015	61,950	27,528
73/74	122,452	2222	5,604	72,503	56,976	26,105
74/75	124,443	2100	5,864	70,571	57,175	30,190
75/76	133,080	2151	7,178	70,286	65,066	38,036
76/77	143,518	1708	3,980	69,463	59,703	56,368
77/78	128,299	2105	5,555	74,877	61,989	53,355
78/79	143,015	2409	5,107	75,054	70,264	56,186
79/80	145,902	2333	4,823	75,979	82,152	48,781
80/81	154,753	2287	4,615	76,663	84,856	46,627
81/82	179,046	2370	5,131	80,541	97,231	54,048
82/83	185,583	2436	3,693	82,910	94,764	65,752
83/84	185,889	2603	3,231	92,269	98,708	63,994
84/85	199,704	2778	3,417	96,150	98,319	72,647

Sources: World Wheat Statistics, I.W.C., various issues.

Notes: Exporting regions were Australia, Argentina, Canada, U.S.A and E.E.C. E.E.C. figures for 1960 to 1962 only represent values from France, 1963 to 1966 are the six member states 1967 to 1980 are nine while 1981 to 1984 are ten states.

APPENDIX D: POPULATION DATA

TABLE D:1

Population Data Series
(in millions)

Year	World	Exporting Countries	Soviet Union	Rest of the World
1960	3,003	275.3	214.1	2,513.6
1961	3,055	279.7	218.0	2,557.3
1962	3,109	284.4	221.4	2,603.3
1963	3,163	416.4	224.8	2,521.8
1964	3,234	422.0	227.7	2,584.3
1965	3,295	427.6	230.9	2,636.6
1966	3,355	438.4	233.5	2,683.1
1967	3,420	499.5	236.0	2,684.5
1968	3,490	504.0	238.3	2,747.7
1969	3,561	508.9	240.6	2,811.5
1970	3,610	514.4	242.8	2,852.8
1971	3,679	517.8	245.1	2,916.1
1972	3,748	522.3	247.5	2,978.2
1973	3,818	526.3	249.7	3,042.0
1974	3,890	529.8	252.0	3,108.2
1975	4,033	533.5	254.4	3,245.1
1976	4,107	536.2	256.7	3,314.1
1977	4,182	539.2	258.9	3,383.9
1978	4,258	542.3	261.2	3,454.5
1979	4,336	545.8	263.5	3,526.7
1980	4,415	555.5	265.5	3,594.0
1981	4,528	569.4	267.7	3,690.9
1982	4,607	573.4	269.9	3,763.7
1983	4,684	576.9	272.5	3,834.6
1984	4,760	580.3	275.1	3,904.6

Source: United Nations Statistical Yearbooks, various issues.

APPENDIX E: PRICES AND DEFLATORS

TABLE E:1

Wheat and Rice Prices with OECD Consumer Price Index
(1980 = 100)
(U.S.\$ / metric ton)

Year	World Wheat Import Price	Soviet Wheat Import Price	Soviet Rice Import Price	OECD All Item CPI
1960	74	79	120	30.4
1961	76	69	119	30.9
1962	74	72	134	31.7
1963	73	69	128	32.5
1964	75	67	132	33.3
1965	60	63	139	34.3
1966	62	64	147	35.5
1967	63	71	169	36.6
1968	62	73	183	38.1
1969	60	72	174	39.9
1970	71	63	151	42.1
1971	75	65	141	44.3
1972	76	64	146	46.4
1973	107	67	232	50.1
1974	189	111	428	56.8
1975	191	177	403	63.2
1976	172	166	325	68.7
1977	149	142	330	74.8
1978	155	116	398	80.7
1979	181	164	385	88.6
1980	211	199	416	100.0
1981	214	214	468	110.5
1982	195	188	398	119.1
1983	185	181	369	125.4
1984	177	172	365	131.8

Sources: Trade Yearbook, F.A.O., various issues.
O.E.C.D Economic Indicators Historical Handbook, O.E.C.D, March, 1984.

APPENDIX F: OTHER SOVIET DEMAND VARIABLES

TABLE F:1

Soviet Income, Cattle Inventories, Forage Production
and Relative Wheat Production

Year	Annual Income (Rubles/Yr)	Cattle Inventories (mil. head)	Forage Production (mil ton O.E.)	Wheat Share of Total Grain Production
1960	967.2	74.2	144.7	0.51
1961	1,006.8	75.8	120.9	0.51
1962	1,040.4	82.1	121.5	0.50
1963	1,058.4	87.0	104.8	0.46
1964	1,089.6	85.4	138.7	0.49
1965	1,158.0	87.1	115.9	0.49
1966	1,202.4	93.4	135.0	0.59
1967	1,256.4	97.1	134.8	0.52
1968	1,352.4	97.2	135.4	0.55
1969	1,402.8	95.7	136.4	0.49
1970	1,464.0	95.2	144.4	0.53
1971	1,510.8	99.2	144.1	0.55
1972	1,562.4	102.4	139.7	0.51
1973	1,618.8	104.0	176.3	0.49
1974	1,693.2	106.3	153.6	0.43
1975	1,749.6	109.1	137.9	0.47
1976	1,815.6	111.0	173.2	0.43
1977	1,861.2	110.3	165.6	0.47
1978	1,917.6	112.7	176.6	0.51
1979	1,957.2	114.1	158.3	0.50
1980	2,023.2	115.1	166.5	0.52
1981	2,065.2	115.1	157.2	0.50
1982	2,122.8	115.9	182.7	0.48
1983	2,178.0	117.2	194.6	0.42
1984	2,232.0	119.6	187.3	0.43

Sources: USSR Situation and Outlook Reports, USDA, various issues.
Economic Survey of Europe, United Nations, 1985.
Prospects for Soviet Agricultural Production and Trade, OECD, 1983.